1050 High Occupancy Vehicle Facilities

1050.01 General

The high occupancy vehicle (HOV) is a transit vehicle, van, car, or any other vehicle that meets the occupancy requirements of a particular facility. Motorcycles and buses (with a capacity of 20 or more) can legally travel in an HOV lane regardless of occupancy level. Vehicles with a gross vehicle weight over 4 500 kg (10,000 lbs.) are not allowed in HOV lanes.

The specific objectives for the HOV system are:

- Improve the capability of congested freeway corridors to move more people by increasing the number of persons per vehicle.
- Provide travel time savings and a more reliable trip time to HOVs that use the facilities.
- Provide safe travel options for HOVs without unduly affecting the safety of the freeway general-purpose lanes.

HOV facilities should be designed and constructed to ensure intermodal linkages, with consideration given to future highway system capacity needs. Whenever possible, HOV facilities should be designed so that the level of service for the general-purpose lanes will not decrease.

In those urban corridors that do not currently have planned or existing HOV facilities, a thorough analysis of the need for HOV facilities should be completed before proceeding with any projects for additional new general-purpose lanes. In those corridors where both HOV and general-purpose facilities are planned, the HOV facility should be constructed before or simultaneously with the construction of new general-purpose lanes.

1050.02 Definitions

arterial HOV a priority treatment(s) for buses, carpools, and vanpools on nonlimited access roadways

buffer-separated HOV facility an HOV lane(s) that is separated from adjacent general-purpose freeway lanes by a designated buffer width 0.6 to 1.2 m (2 to 4 ft) or greater than 2.4 m (8 ft)

concurrent flow lane a buffer or nonseparated lane on which HOVs operate in the same direction as the normal traffic flow

contraflow lane a lane on which HOVs operate in a direction opposite to that of the normal flow of traffic

direct access ramp a grade-separated on or off ramp that provides local access from a street or transit support facility to the freeway HOV facility

enforcement area a place where vehicles may be stopped for ticketing by law enforcement. It also may be used as an observation point and for emergency refuge

enforcement observation point a place where an officer may park and observe traffic

flyover ramp a grade-separated usually high-speed facility that provides ingress and egress over a freeway HOV main line facility to a local arterial street, another freeway, or another HOV support facility

high occupancy vehicle (HOV) a transit vehicle, van, car or any other vehicle that meets the occupancy requirements of a particular facility

level of service a descriptive measure of the quantity and quality of transportation service provided the user that incorporates finite measures of quantifiable characteristics such as travel time, travel cost, number of transfers, etc.

line enforcement enforcement by means of travel in the HOV lane or in the adjacent general-purpose lane

occupancy designation the minimum number of occupants for a vehicle to use the facility

separated HOV facility an HOV lane that is physically separated from adjacent general-purpose freeway lanes

shy distance the width between the outside edge of the shoulder and the traffic barrier or other obstruction

single occupant vehicle (SOV) motor vehicles other than a motorcycle carrying one occupant

stationary enforcement enforcement by vehicles parked in enforcement areas, on and off ramps, and at locations with high violation rates. The officer can wave the violator over, and ideally, pursuit is not necessary.

violation rate the total number of violators divided by the total number of vehicles on an HOV facility

1050.03 References

Guide for the Design of High Occupancy Vehicle Facilities, American Association of State Highway and Transportation Officials

Manual on Uniform Traffic Control Devices for Streets and Highways, M 24-01, U.S. Department of Transportation, Federal Highway Administration

Design Features of High Occupancy Vehicle Lanes, Institute of Traffic Engineers

Washington State Freeway HOV System Policy, Washington State Department of Transportation

Standard Plans for Road, Bridge and Municipal Construction, M 21-01, Washington State Department of Transportation

Traffic Manual, M 51-02, Washington State Department of Transportation

High-Occupancy Vehicle Facilities: Current Planning, Operation and Design Practices, Parsons Brinkerhoff, Inc.

1050.04 Preliminary Design and Planning

(1) Planning Elements for Design

In order to determine the appropriate design options for an HOV facility, the travel demand and capacity must first be established. Suitable corridors must be identified, the HOV facility location and length evaluated, and the HOV demand must be estimated. A viable HOV facility will satisfy the following criteria:

- Part of an overall transportation plan.
- Have the support of the community and public.
- In response to demonstrated congestion or near-term anticipated congestion (Level of Service E or F for at least one hour of peak period, traffic approaching a capacity of 1,700 to 2,000 vehicles per hour per lane, and/or average speeds less than 50 km/h (30 mph) during peak periods over an extended distance).
- Except for a bypass of a local bottleneck, HOV facilities will be of sufficient length to provide a travel time saving of at least 5 minutes during the peak periods.
- Sufficient number of HOV users for a cost-effective facility and to avoid the perception of under utilization. (HOV volumes of 400 to 500 vehicles per hour on concurrent flow lane and 600 to 800 on separated facilities.)
- A design that provides for safe, efficient, and enforceable operation.

A queue bypass treatment does not need to justify all of the above to be effective. Isolated bypasses may be warranted when there is localized, recurring traffic congestion, and such treatment will provide a travel time saving to an adequate number of HOV users.

Particular attention must be given to the ingress and the egress to the facility. The efficiency of the HOV facility can be greatly affected by the access provisions. Direct access to and from the HOV facility would be the most desirable, but it is also an expensive alternative. Direct access options are discussed in 1050.04(3)(d). The termination of an HOV lane should be safe and efficient. See the discussion in 1050.06(6).

The design report should address the need for the facility and how the facility will meet those needs in accordance with the above criteria.

(2) HOV Facility Type

A determination must be made as to the type of HOV facility. For freeways, the three major choices are separated roadway, concurrent flow, and buffer separated.

(a) **Separated Roadway.** The separated roadway can be either a one-way reversible or a two-way operation. The directional split in the peak periods, space available, and operating logistics are factors to be considered. A separated HOV may be located in the median of the freeway, next to the freeway, along the side, or on an independent alignment. Separated HOV facilities are more effective for:

- Large HOV volumes.
- Large merging and weaving volumes that can compromise efficiency of the HOV lane.
- Long-haul HOV travel.

Reversible, separated roadways operate effectively where there are major directional splits during peak periods. Consideration should be given to potential changes in this traffic pattern in the future and designing the facility to accommodate possible conversion to two-way operation in the future. The separated roadway is normally the more efficient, provides for the higher level of safety, and is more easily enforced. However, it is generally the most expensive type of HOV facility to implement.

(b) **Concurrent Flow.** Concurrent flow lanes are an alternate for two-way operation. Concurrent flow HOV lanes operate in the direction of the freeway lanes immediately adjacent to the general-purpose lanes. They are located either to the inside or outside of the general-purpose lanes. Refer to Figure 1050-1. This type of facility is normally less costly, is easier to implement, and provides more opportunity for frequent access. However, the ease of access also can create more problems for enforcement and higher potential for conflicts, particularly considering the speed differential between the HOV lane and the mixed traffic lanes. These operational shortcomings can be alleviated somewhat by the use of a buffer between the HOV lane and the general-purpose lanes.

(c) **Buffer Separated.** The buffer separated HOV facility is similar to the concurrent flow HOV, but with a 0.6- to 1.2-m (2- to 4-ft) buffer (or greater than 2.4 m [8 ft]) between the HOV lane and the general-purpose lanes. The addition of a buffer provides better delineation between the lanes and an improved operation, considering the speed differential between the lanes.

(3) Operational Alternatives

In addition to the HOV facility, a full range of operational alternates must be considered before preparing a project prospectus. For limited access facilities, the operational alternates include:

- Inside or outside HOV lane.
- Lane conversion.
- Use of existing shoulder.
- Direct access.
- Queue bypasses.
- Transit flyer stops.

When evaluating alternates, it must be realized that a combination of alternates may provide the best solution for the corridor. Also, flexibility must be incorporated into the design in order not to preclude potential changes in operation, such as outside-to-inside lane and reversible to two-way operations. Access, freeway-to-freeway connections, and enforcement would have to be accommodated for such changes.

(a) **Inside Versus Outside HOV Lane.** System continuity and consistency of HOV lane placement along a corridor are important and influence facility development decisions. Issues that should be considered include land use, trip patterns, transit vehicle service, HOV main line and ramp volumes, main line congestion levels, safety, enforcement, and direct access to facilities.

The inside HOV lane (left lane) is most appropriate for a corridor with long distance trip patterns, such as a freeway providing mobility to and from the central business district or a large activity center. These trips are characterized by long haul commuters and express transit vehicle service. Maximum capacity for an effective inside HOV lane is approximately 1,500 vehicles per hour. When HOV volumes exceed 1,500 vehicles per hour, the HOVs weaving across the general-purpose lanes may cause severe congestion. In these situations consideration should be given to implementing direct access HOV ramps, physically separated HOV roadways, or providing a higher occupancy designation.

The outside HOV lane (right lane) is most appropriate for a corridor with shorter, widely dispersed trip patterns such as a freeway that encircles the central business district and provides mobility for the suburb-to-suburb commuters. These trip patterns are characterized by transit vehicle routes that exit and enter at nearly every interchange. The maximum capacity for an effective outside HOV lane is approximately 1,100 vehicles per hour. Capacity is reduced and potential conflicts are increased by heavy main line congestion and large entering and exiting general-purpose volumes since they must cross through the HOV lane.

(b) **Conversion of a General-Purpose Lane.** Conversion of a general-purpose lane to an HOV lane may be justified when the conversion provides greater people-moving capability on the roadway. Given sufficient existing capacity, converting a general-purpose lane to an HOV lane will provide for greater people moving capability in the future without significantly affecting the existing roadway operations. From an engineering standpoint, the fastest and least expensive method for providing an HOV lane is through conversion of a general-purpose lane. Striping and signing are sometimes the only engineering features that need be implemented. Converting a general-purpose lane to HOV use would likely have long-term environmental benefits. This method, however, is controversial from a public acceptance standpoint. Public support may be gained through an effective public involvement program. See Chapter 210, Public Involvement and Hearings.

Lane conversion of a general-purpose lane to an HOV lane must enhance the corridor's people moving capacity. It is critical that an analysis be conducted. This analysis shall address:

- Public acceptance of the lane conversion.
- Present and long-term traffic impacts on the adjacent general-purpose lanes and the HOV lane.
- Impacts to the neighboring streets and arterials.
- Legal, environmental, and safety impacts.

The analysis must reflect an overall increase in people moving capacity, and this analysis must be included in the design report.

(c) **Use of Existing Shoulder.** When considering the alternatives in order to provide additional width for an HOV lane, the use of the existing shoulder is not a preferred option. To use the existing shoulder is a design deviation and approval is required.

Shoulder conversion to an HOV lane should only be used when traffic volumes are heavy and the conversion is a temporary measure. Another alternative would be to use the shoulder as a permanent measure to serve as a transit-only lane during peak hours and then reverted to a shoulder in off peak hours. The use of the shoulder creates special signing, operational, and enforcement problems. An agreement must be executed with the transit agency to ensure that transit vehicles will only use the shoulder during peak hours. The use of the shoulder must be clearly defined by signs which include the words TRANSIT ONLY and SHOULDER. Special operations should be instituted to ensure the shoulder is clear and available for the designated hours. These operational alternatives must be documented in the design report.

The existing shoulder pavement is often not designed to carry heavy volumes of HOVs, especially transit vehicles. As a result, repaving and reconstruction of the shoulder may be required.

(d) **Direct Access.** To maximize the efficiency of the HOV system, exclusive HOV access ramps for an inside HOV lane are recommended. Direct access eliminates the HOV user crossing the general-purpose lanes since most of the main line ingress and egress movements are from the outside (right side). Also, transit vehicles will be able to use the HOV lane and provide service to frequently spaced interchanges.

Providing the HOV user access to the inside HOV lane without mixing with the general-purpose traffic saves the user additional travel time and aids in safety and enforcement, incident handling, and overall operation of the HOV facility.

Key locations for direct access ramps include park and ride lots and flyer stop interchanges. Coordination with the local transit agencies will result in the identification of these key locations. Priority should be given to locations that serve the greatest number of transit vehicles and other HOVs. Transit agencies may provide funding for the construction of a direct access ramp that serves transit vehicles.

Direct access of any type is usually very expensive due to the structural and right of way requirements. If direct access ramps are not included in the initial project, provisions should be made so that they can be added later or at least the design should not preclude their addition at a later date.

(e) **Queue Bypass Lanes.** The type of congestion, the HOV demand, or the physical roadway characteristics may warrant a short, preferential treatment that allows HOVs to save time by avoiding congestion at an isolated bottleneck. The bottleneck may be operational due to capacity restrictions or artificially introduced by metering. An acceptable range of time savings for queue bypasses are one to three minutes, although much larger time savings may be experienced, particularly at metering sites. Typical locations for queue bypasses are at ramp meters, signalized intersections, toll plaza or ferry approaches, and parallel facilities in conjunction with isolated main line congestion. By far the most common use is with ramp metering. This type of treatment can be accomplished along with a corridor HOV facility or independently. In most cases, these treatments are relatively low cost and can be readily implemented. HOV bypasses should be included on all ramp metering sites or provisions made for the future accommodation, unless specific location conditions dictate otherwise.

(f) **Transit Flyer Stops.** A variation of direct access is to provide a flyer stop (also known as express transit stations) where transit vehicles traveling on the freeway stop alongside the freeway on a special ramp constructed for transit vehicle use only. Pedestrians access the flyer stop by way of stairs, wheelchair accessible ramps, and elevators. Ideally, the flyer stop is separated by barriers from the rest of the freeway.

1050.05 Operations

(1) Vehicle Occupancy Designation

The vehicle occupancy designation should provide for the maximum movement of people in a corridor, provide free-flow HOV operations, reduce the empty lane perception, provide for the ability to accommodate future HOV growth within a corridor, and be consistent with the regional transportation plan and the policies adopted by the metropolitan planning organization (MPO).

An initial occupancy designation must be established, but it is not critical that this initial occupancy level be based on detailed traffic projections and usage for the design year since the requirements can be changed as operational conditions warrant in the future. It is WSDOT policy to use the 2+ designation as the initial occupancy designation. The 2+ carpools are easier to establish and will provide the higher vehicle utilization. A 3+ occupancy designation should be considered if it is anticipated during initial operation that the volumes will be 1,500 vehicles per hour for a left side HOV lane, or 1,200 vehicles per hour for a right-side HOV lane, or that a 70 km/h (45 mph) operating speed cannot be maintained for more than 90 percent of the peak hour.

In air quality nonattainment areas where transportation sources are a significant cause of pollution, a change in the vehicle occupancy designation is subject to analysis by the MPO.

A possible option is a variable 2+/3+ occupancy designation providing access to the HOV lane for the 3+ HOV users during the peak hours and 2+ HOV users in the nonpeak hours. A variable definition alleviates the under utilization of an HOV lane and allows for a reliable level of service during peak hours. The use of a combination of both fixed and changeable message signing should be considered to indicate a variable carpool designation. Adequate signing and accommodation of enforcement needs must be included in this decision. Coordination with the enforcement agency(s) and an evaluation of the consistency with regional plans and policies is required before implementing this option.

(2) Hours of Operation

WSDOT policy is to provide 24 hours a day HOV designation on freeway HOV lanes. There may be special situations where part time operation during the peak period is appropriate. This involves more complicated signing and enforcement considerations. Additionally, if it involves a shoulder or parking lane that reverts back to its normal usage, special operations should be instituted to ensure the shoulder or lane is clear and available for the designated hours. These operational alternatives must be documented in the design report.

(3) Enforcement

Enforcement is essential to the success of an HOV facility. It shapes public attitudes and maintains the integrity of the facility. Coordination with the Washington State Patrol is critical when the operational characteristics and design alternatives are being established. This involvement ensures that the project is enforceable and will receive their support.

Any high-speed HOV facility shall provide both enforcement areas and observation points. Ramp facilities also need enforcement areas although the design requirements will be different due to their location and reduced speeds.

Barrier-separated facilities, because of the limited access to SOV violators, are the easiest facilities to enforce. Shoulders provided to accommodate breakdowns may also be used for enforcement. Reversible barrier-separated facilities have dead ramps for the reverse direction that may be used for enforcement. Breaks in the barrier may be needed so emergency responders can access barrier separated HOV lanes and back up to the accident.

Buffer-separated and concurrent flow facilities allow violators to enter and exit the HOV lane at will. For this reason, providing strategically located enforcement areas and observation points is essential.

Consider the impact on safety and visibility for the overall facility during the planning and design of enforcement areas and observation points. Where HOV facilities do not have enforcement areas, or where officers perceive that the enforcement areas are inadequate, enforcement on the facility will be difficult and less effective.

(4) SC&DI

The objective of the Surveillance, Control and Driver Information (SC&DI) system is to make more efficient use of our transportation network. This is done by collecting data, managing traffic, and relaying information to the motoring public.

It is important that an SC&DI system is incorporated into the HOV project and that the HOV facility fully utilize the SC&DI features available. This includes providing a strategy of incident management since vehicle breakdowns and accidents have a significant impact on the efficient operation of both the HOV facilities and the general-purpose lanes.

1050.06 Design Criteria

(1) Design Procedures

HOV projects that add or reconstruct HOV facilities are to be considered as new construction. A design report is required for all HOV projects (including lane conversion alternatives). Refer to Chapter 330, *Design Reports*, for design report procedures.

(2) Design Considerations

For freeway facilities, the design elements such as horizontal and vertical alignment, vertical clearance, cut and fill slopes for both sides of the freeway, sight distance, weave areas within interchanges, and superelevation shall conform to the criteria in Division 6, Geometrics, and Division 9, Interchanges and Intersections. The roadside safety principles in Division 7 are also applicable.

The design vehicle for HOV facilities should include passenger vehicles, vans, and single unit and articulated buses. Turning roadway widths for HOV on and off ramps shall conform to Figure 1050-2. The design speeds, as a minimum, should be comparable to the general-purpose facilities. The design criteria for paving sections, vehicle characteristics and intersection radii should conform to Chapter 1060, *Transit Benefit Facilities.*

(3) Adding an HOV Lane

The options for adding an HOV lane are reconstruction, restriping, combined reconstruction and restriping, and possibly lane conversion.

Reconstruction involves creating additional traffic lanes by widening to the inside (left side), the outside (right side), or both. Additional right of way may be required. Restriping involves reallocating the existing paved roadway to create enough space to provide an additional HOV lane. Restriping of lane widths to less than 3.6 m (12 ft) is a design deviation and approval is required.

Reconstruction and restriping can be combined to maximize use of the available right of way. For example, a new lane can be created through a combination of median reconstruction, shoulder reconstruction, and lane restriping. Each project will be handled on a case by case basis. Generally the following reductions should be considered in order of preference:

(a) Reduction of the inside shoulder width, provided the enforcement and safety mitigation issues are addressed. (Consideration shall be given not to preclude future direct access by over reduction of the available median width.)

(b) Reduction of the interior general-purpose lane width to not less than 3.3 m (11 ft).

(c) Reduction of the outside general-purpose lane width to not less than 3.3 m (11 ft).

(d) Reduction of the HOV lane to not less than 3.3 m (11 ft).

(e) Reduction of the outside shoulder width from 3.0 to 2.4 m (10 ft to 8 ft).

If lane width adjustments are necessary, old lane markings must be thoroughly eradicated. It is desirable that longitudinal joints (new or existing) not conflict with tire track lines. If they do, then consideration should be given to overlaying the roadway before restriping.

(4) Design Criteria for Types of HOV Facilities

(a) **Barrier-Separated HOV Facilities.** The separated HOV facility can be single lane or multilane and directional or reversible. A single lane roadway shall have a minimum cross section of 7.9 m (26 ft) (Figure 1050-3a). A two-lane roadway shall have a minimum width of 11.4 m (38 ft) (Figure 1050-3b).

(b) **Concurrent Flow HOV Lanes.** Concurrent flow HOV lanes are lanes that operate in the same direction as the adjacent freeway lanes and are located either on the outside or inside of the general-purpose lanes (Figure 1050-1).

For both inside and outside HOV lanes, the standard lane width is 3.6 m (12 ft) and the standard shoulder width is 3.0 m (10 ft). Approval of a design deviation is required for lane widths less than 3.6 m (12 ft) and shoulder widths less than 3.0 m (10 ft).

When it is proposed that the inside shoulder be less than 3.0 m (10 ft) for distances exceeding 2.5 km (1.5 mi), enforcement and observation areas must be provided at 1.5- to 3-km (1- to 2-mi) intervals. See Figures 1050-7a and 7b.

Where inside shoulders of less than 2.4 m (8 ft) are proposed for lengths of roadway exceeding 0.8 km (0.5 mi), safety refuge areas must be provided at 0.8- to 1.6-km (0.5- to 1-mi) intervals. These can be in addition to or in conjunction with the enforcement areas. Dedicated incident response teams, contracted towing, or private assistance patrols located along the corridor or in the immediate vicinity are operational mitigations which can be used along with greater spacing between refuge areas. These measures are to provide for the efficient operation and free flow capabilities of the corridor.

A buffer separated HOV facility is a variation of the concurrent flow lanes in which a buffer is provided between the faster moving HOV traffic and the general-purpose traffic to increase safety and driver confidence. The design standards are the same as for the concurrent flow HOV lanes, except for a buffer 0.6 to 1.2 m (2 to 4 ft) in width or greater than 2.4 m (8 ft) in width. Buffer widths between 1.2 and 2.4 m (4 and 8 ft) are not considered desirable since they may be mistakenly used as a refuge area for which they would be inadequate.

(c) **HOV Ramp Bypass.** The HOV bypass may be created by widening an existing ramp, construction of a new ramp where right of way is available, or reallocation of the existing pavement width provided the shoulders are full depth.

Ramp meter bypass lanes are located on the left or right of metered lane(s). Typically, bypass lanes are located on the left side of the ramp. Consult with local transit agencies and the region's Traffic Office for direction on which side (left or right) to place the HOV bypass.

The design of the ramp meter should be determined by the existing conditions at each location. See Figure 1050-4a for the typical single lane ramp meter with HOV bypass and Figure 1050-4b for the typical two lane ramp meter with HOV bypass.

Both Figures, 1050-4a and 4b, show the required 4.2-m (14-ft) wide observation point/enforcement area. Any other design must be treated as a design exception and documented accordingly. One alternative (a design exception) is to provide a 3.0-m (10-ft) outside shoulder from the stop bar to the main line.

(5) Direct Access Connections

Direct access ramps, such as Figure 1050-5a and 5b, provide access between the inside HOV facilities (barrier separated or concurrent flow) to another freeway, a local arterial street, or a park and ride facility, by way of an elevated structure.

The design for a single-lane on ramp located on the left side of the main line is shown on Figure 1050-5c.

A less expensive alternative to a flyover ramp is a slip ramp (Figure 1050-6). Slip ramps provide access to and from the barrier separated facility from the inside main line lane. As a result of the operational problems associated with a left-hand slip ramp, a thorough operational analysis should be conducted and adequate signing should be provided.

(6) HOV Lane Termination

The beginning and end of an HOV facility should be at logical points and should typically avoid existing freeway ramps. There should be adequate sight distance at the terminals, and adequate signing and pavement markings must be provided.

For the termination of an HOV lane, the principles that apply to merge or diverge maneuvers should be used. When the HOV lane is on the inside of the freeway, the desirable or higher values should be used since the interface is with the "fast" lane.

The preferred method is to provide a straight-through move into a mixed-flow lane and drop a general-purpose lane. However, volumes for both the HOV lanes and general-purpose lanes, and the geometric conditions should be analyzed so that the operational performance of the general-purpose lanes is not compromised.

(7) Enforcement Areas

Enforcement of the inside concurrent flow HOV lane can be done with a minimum 3.0-m (10-ft) inside shoulder. For continuous lengths of barrier exceeding 3 km (2 mi), a 3.0-m (10-ft) shoulder with a 0.6-m (2-ft) shy distance is recommended.

For inside shoulders less than 3.0 m (10 ft), enforcement and observation areas shall be located at 1.5- to 3-km (1- to 2-mi) intervals or based on the recommendations of the Washington State Patrol. These areas can also serve as safety refuge areas for disabled vehicles. Refer to Figure 1050-7a and 7b.

Observation points should be constructed approximately 400 m (1300 ft) before enforcement areas. They can be designed to serve both patrol cars and motorcycles or motorcycles only. Coordination with Washington State Patrol is essential during the design stage to provide effective placement and to ensure utilization of the observation points. Median openings give motorcycle officers the added advantage of being able to quickly respond to emergencies in the opposing lanes. See Figure 1050-7c. The ideal observation point places the motorcycle officer a meter or more in elevation above the HOV lane and outside the shoulder so the officer can look down into a vehicle.

The enforcement pad should be located on the right side for queue bypasses and downstream from the stop bar so the officer can be an effective deterrent (Figures 1050-4a and 4b).

An optional one-section signal head with a 200 mm (8 in) red lens (signal status indicator for enforcement) may be placed at HOV lane installations that are metered. The signal head faces the enforcement pad so that Washington State Patrol can determine if vehicles are violating the ramp meter. The signal head allows Washington State Patrol to simultaneously enforce two areas, the meter and the HOV lane. Consult with Washington State Patrol for use at all locations.

Document in the design report the decision regarding the installation of the signal head. Refer to the *Traffic Manual* regarding HOV metered bypasses for additional information on enforcement signal heads.

(8) Signs and Pavement Markings

The *MUTCD* has established pavement markings and signs for preferential lane-use control. Guidance for use of these items is provided in the *Traffic Manual*.

(a) **Signs.** Restricted use HOV signs should be post mounted next to the HOV lane. The sign wording must be clear and precise, stating which lane is restricted, the type of HOVs allowed and the HOV vehicle occupancy designation approved for that section of road. The sign size, location, and spacing is dependent upon the conditions under which the sign is used and should be consistently applied. Refer to the *Traffic Manual* for additional guidance on signing of HOV facilities. Roadside signs can also be used to convey other HOV information such as the HERO program, carpool information telephone numbers, and violation fines. Some situations may call for the use of variable message signs.

Overhead signs should be placed directly over the HOV lane to provide maximum visibility. A sequence of overhead signs shall be used at the beginning and end of all HOV freeway facilities. Overhead signs can also be used in conjunction with roadside signs along the roadway.

(b) **Pavement Markings.** Pavement markings should conform to the *Traffic Manual* and the *Standard Plans for Road Bridge and Municipal Construction.*

(c) **Interchanges.** In the vicinity of interchange on and off connections where merging or exiting traffic crosses an HOV lane, make provisions for general-purpose traffic using the HOV lane. These provisions include signing and striping that clearly show the changes in HOV versus general traffic restrictions. Refer to the *Standard Plans* for pavement markings and signing.

1050.07 Arterial HOV

There are a variety of HOV treatments available for use on arterials. Some of these treatments are site specific or have limited applications. HOV lanes on arterials are increasingly being considered. Arterial HOV lanes differ from freeway HOV lanes in slower speeds, little access control (turning traffic can result in right angle conflicts), traffic signals, and reduced geometric standards. Arterial HOV lanes are occasionally designated for transit vehicles only, especially in major cities with a large concentration of transit vehicles.

Often, arterial HOV lanes are constructed in relatively short lengths to give an advantage to HOVs approaching a signalized intersection. Arterial HOV lanes are usually located on the outside (right) lane of the roadway because the loading and unloading of transit vehicles usually takes place there. If business and cross streets are present, then SOV traffic should be allowed access to the HOV lane to turn.

Turns across and through the arterial HOV lane can create conflicts. Minimizing access points that create these conflict locations, such as by providing well-delineated driveways, is recommended. Adequate signs and pavement markings are important.

The outside of the HOV lane should have either curb or an edge stripe.

Signal priority treatments which alter the sequence or duration of a traffic signal are techniques for providing preferential treatment for transit vehicles and emergency vehicles. The priority treatments can range from timing and phasing adjustments to signal preemption. The priority treatments may require changes in signal controller equipment and provisions for on-board transit vehicle equipment or special detectors to identify transit vehicles, However, the overall impact on traffic must be considered. Preemption would normally not be an appropriate treatment where traffic signal timing and coordination are being utilized or where there are high volumes on the cross streets.

These priority treatments can significantly improve effectiveness and safety of an arterial HOV facility. Modification of the signal system can provide a low cost priority treatment for transit vehicles. The use of these priority treatments must be coordinated with the local transit agencies and approved by the State Traffic Engineer. For further guidance for the use of signal priority treatments, refer to the *Traffic Manual*.

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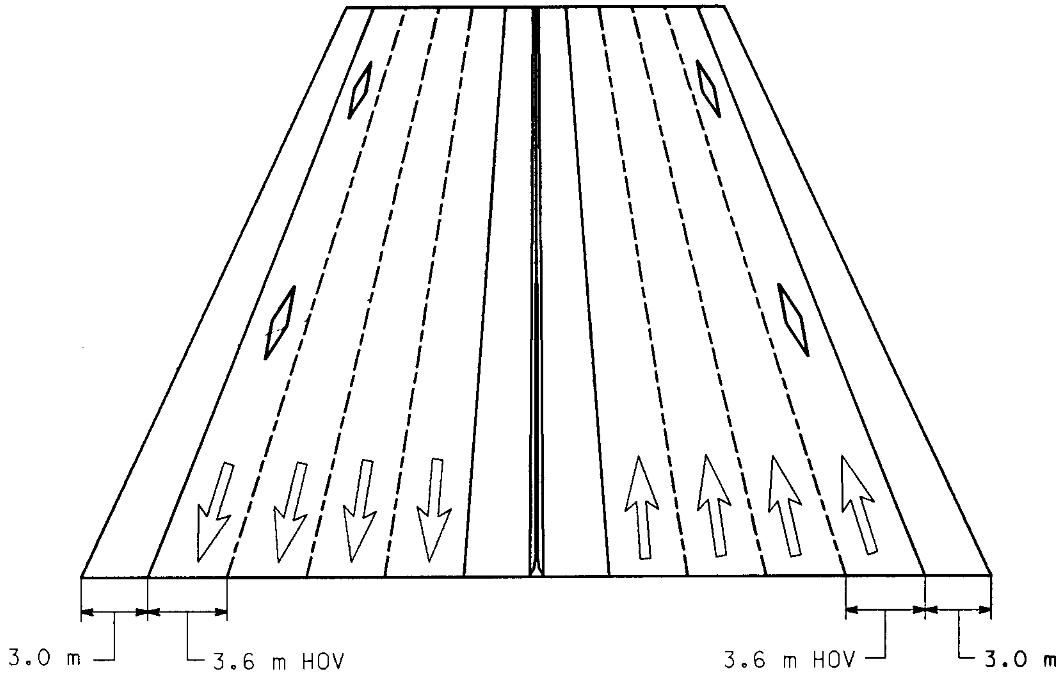
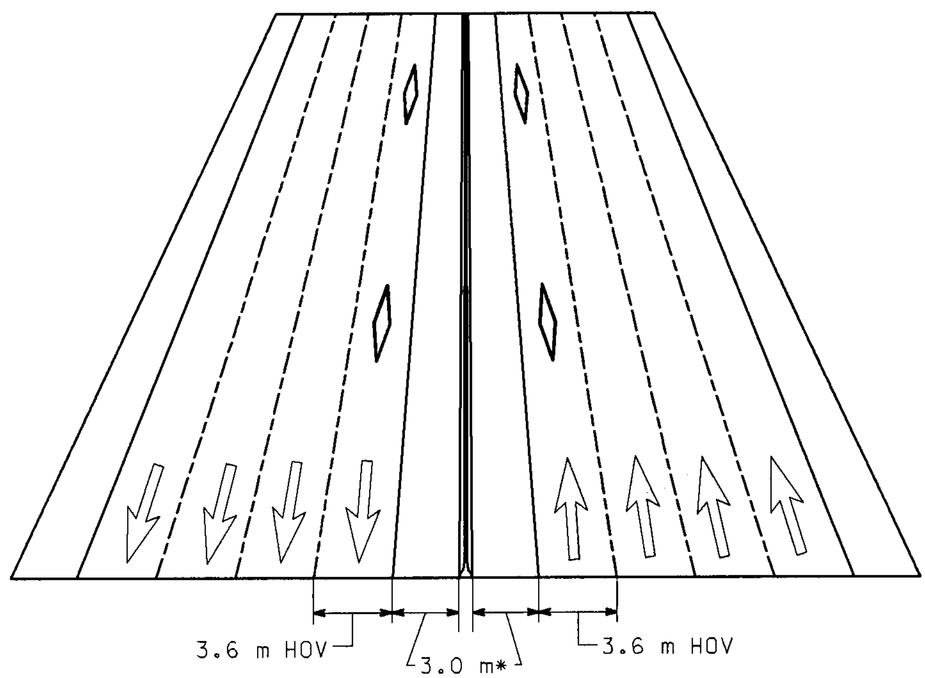


Concurrent flow HOV lanes with outside HOV lanes



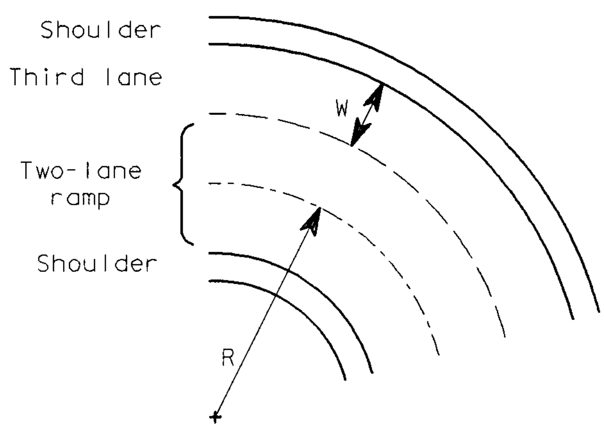
Concurrent flow HOV lanes with median HOV lanes

*For continuous lengths of barrier, a 3.0 m shoulder with a 0.6 m shy distance is recommended to provide an enforceable corridor.

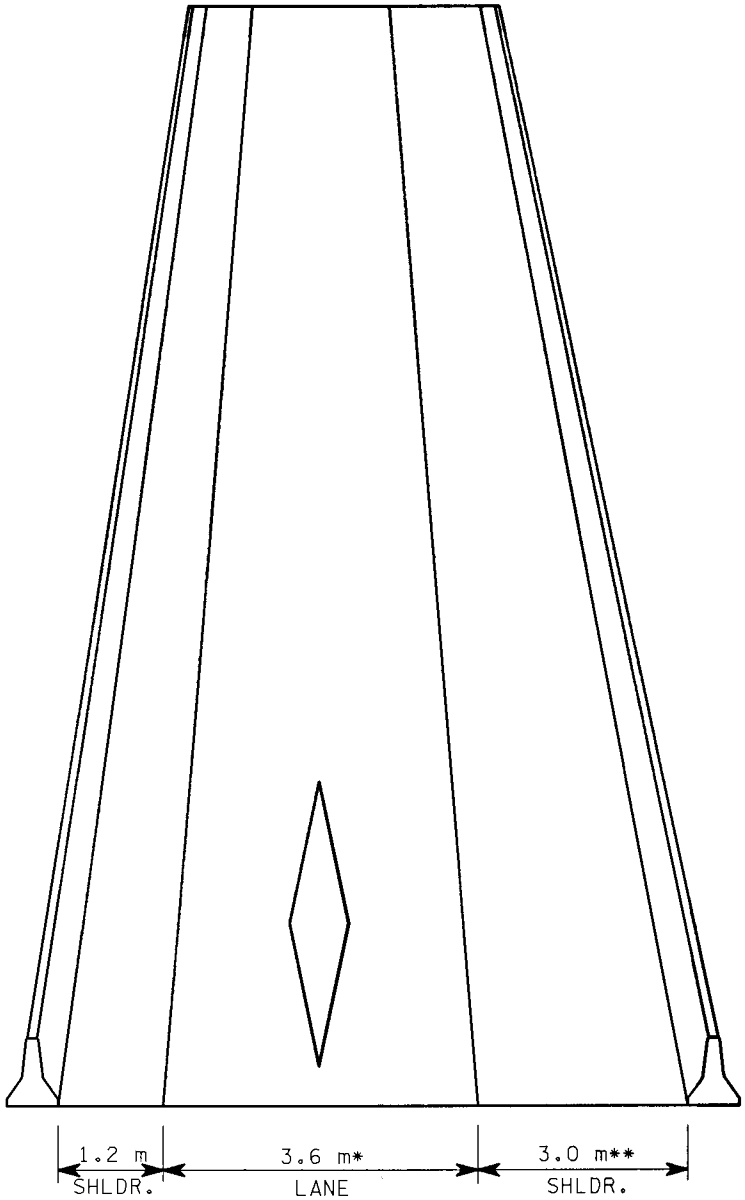
Typical Concurrent Flow Lanes
Figure 1050-1
(Metric)

RADIUS OF TWO-LANE RAMP R (m)	DESIGN WIDTH OF THIRD LANE* W (m)
301 to TANGENT	3.6
300	3.9
180	3.9
150	3.9
120	4.2
105	4.2
90	4.2
75	4.2
60	4.5
45	4.8
30	5.1

* NOTE: Apply additional width to 2-lane ramp widths.
See Chapter 640 for turning roadway widths.



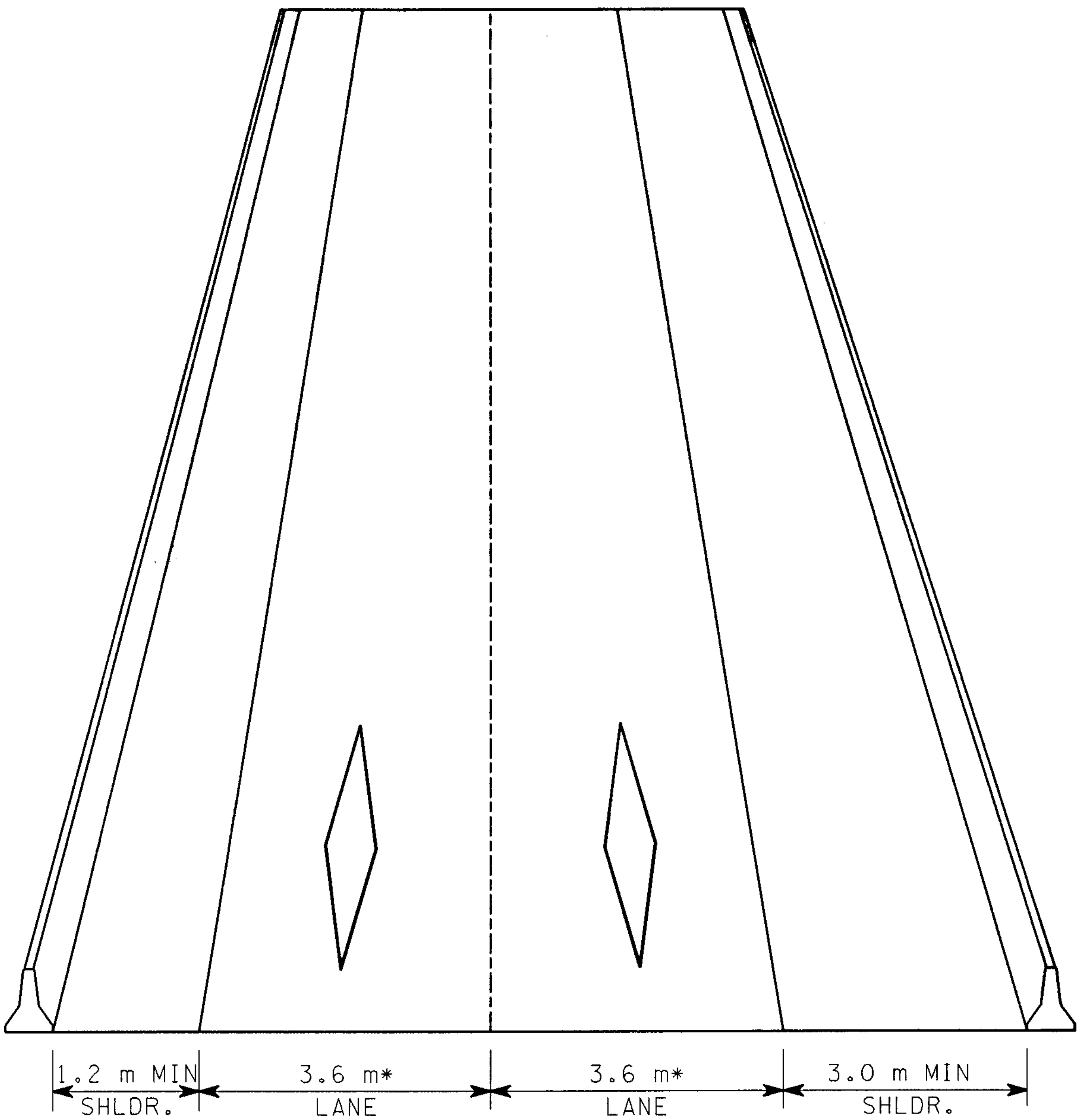
Roadway Widths for Three-Lane HOV On and Off Ramps
Figure 1050-2
(Metric)



*See Chapter 640 for turning roadway widths.

**The use of a 2.4 m shoulder will require a design deviation.

Separated Roadway Single-Lane, One-Way or Reversible
Figure 1050-3a
(Metric)

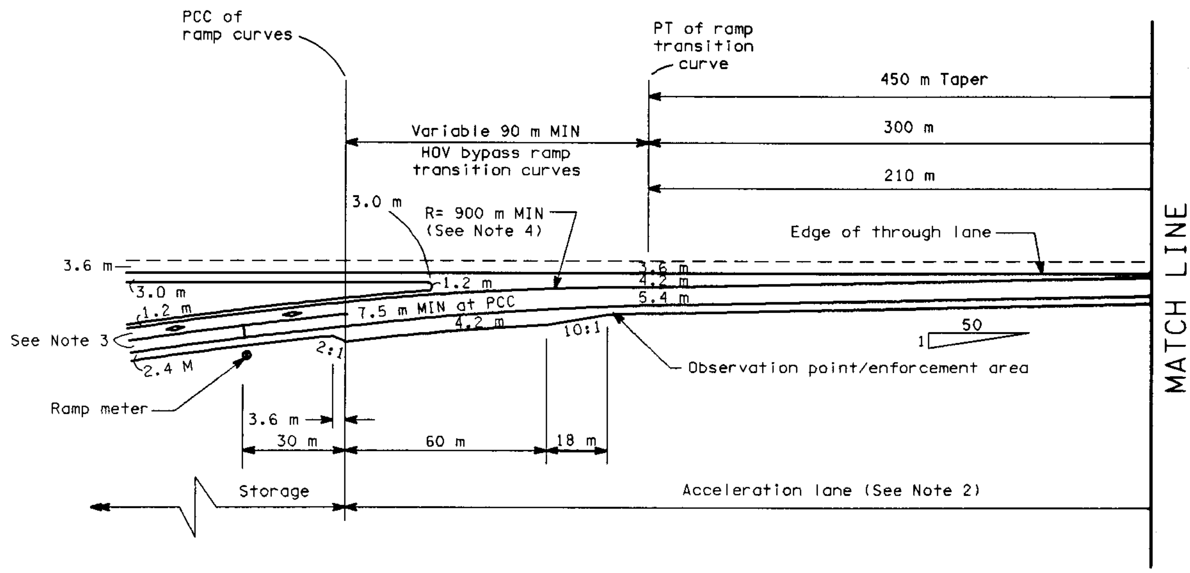


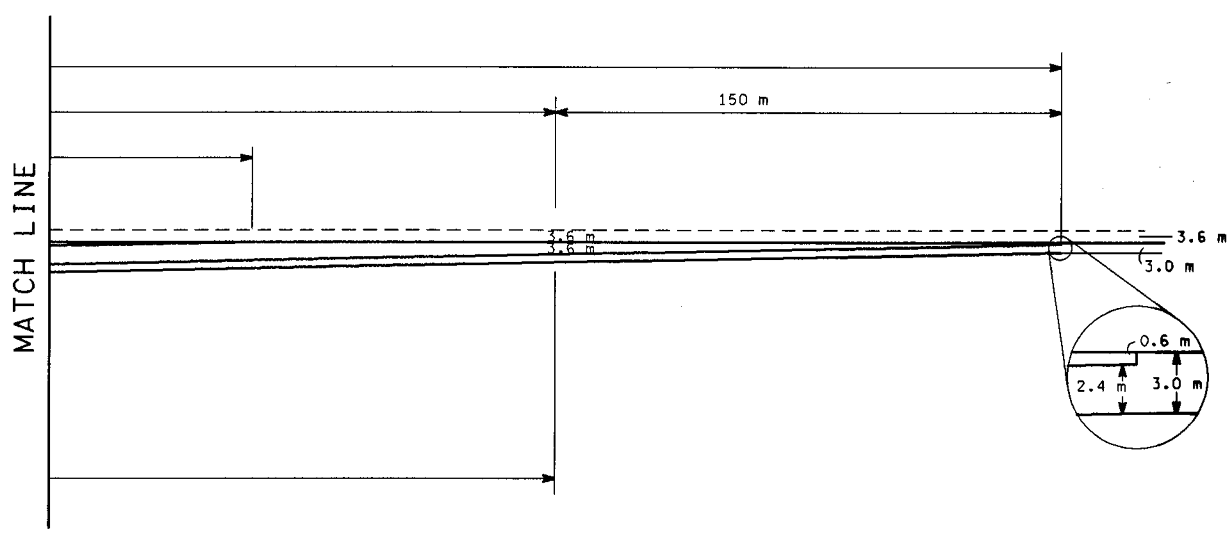
* See Chapter 640 for turning roadway widths.

Separated Roadway Multi-Lane, One-Way or Reversible
Figure 1050-3b
(Metric)

NOTES

1. See Standard Plans for striping details.
2. This distance must equal or exceed the "Acceleration lane length" tabulated in Chapter 940.
3. See Chapter 640 for roadway widths.
4. Use of radii less than 900 m must be justified in the design report.





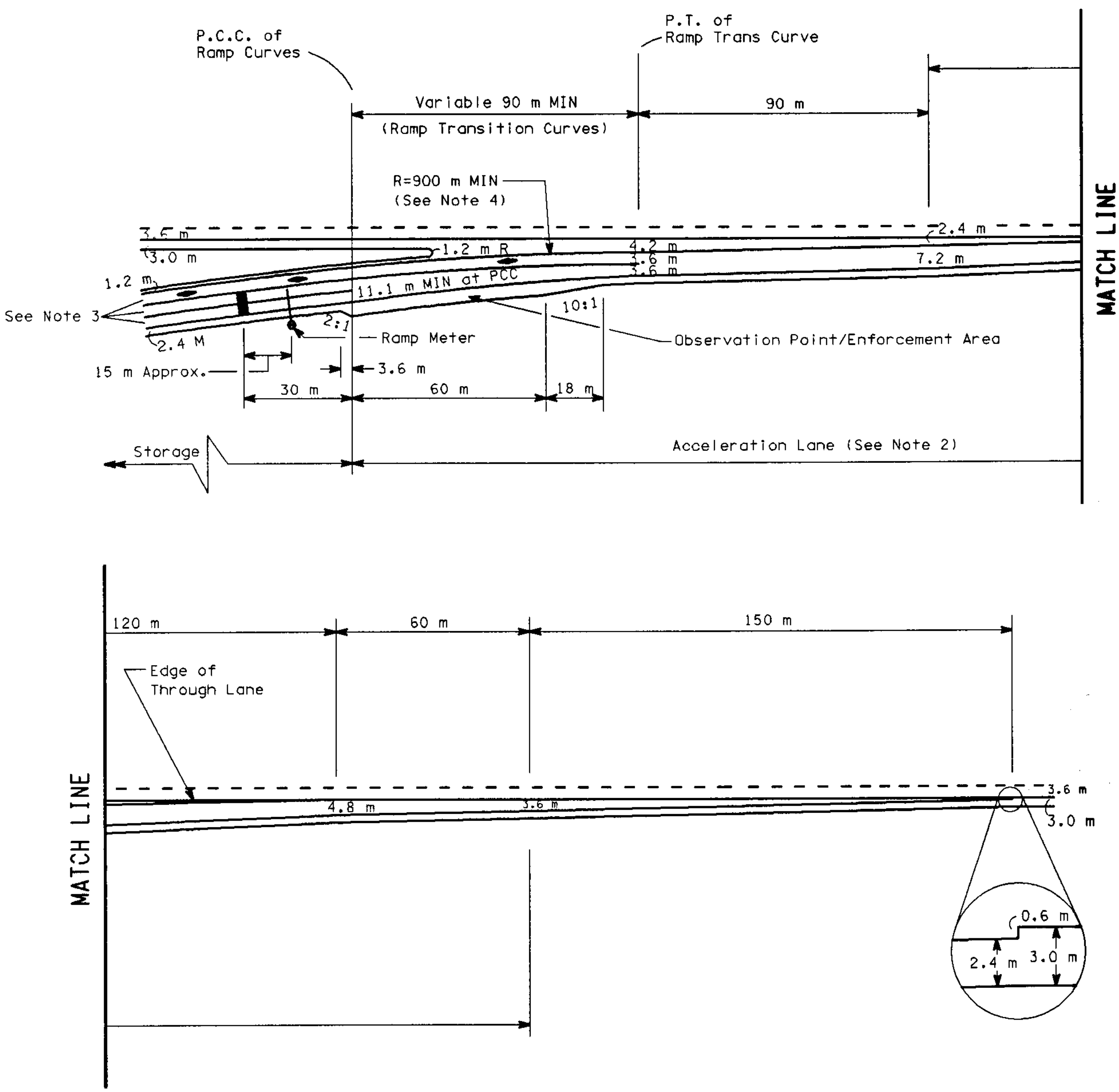
Single-Lane Ramp Meter With HOV Bypass

Figure 1050-4a

(Metric)

NOTES

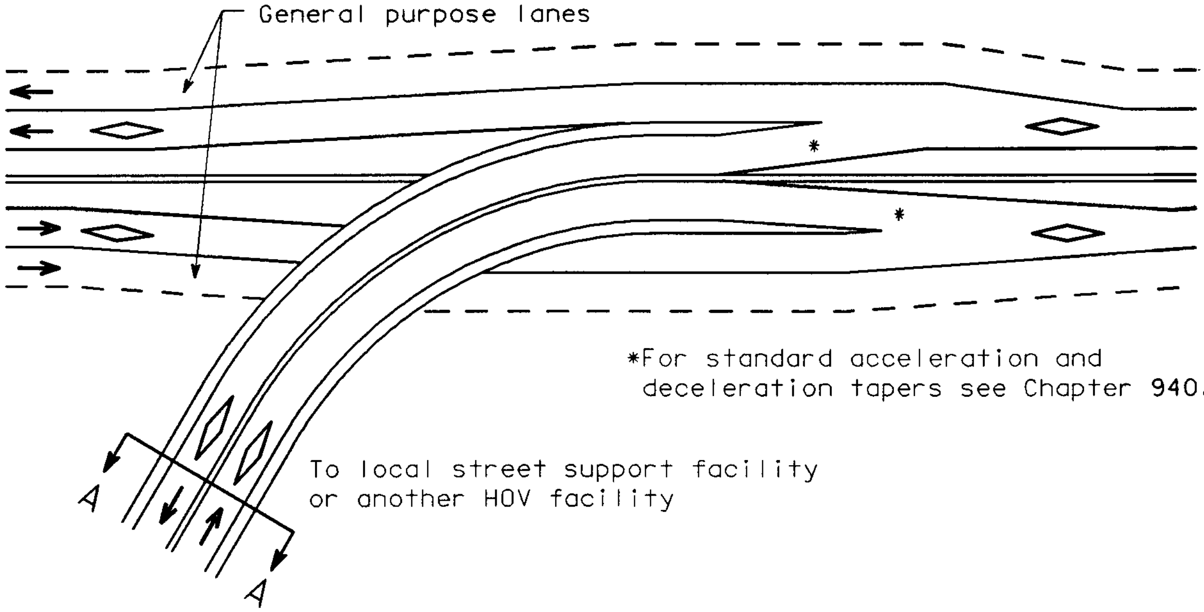
1. See Standard Plans for Striping Details.
2. This distance must equal or exceed the "Acceleration Lane Length" tabulated in Chapter 940.
3. See Chapter 640 and Figure 1050-2 for roadway widths.
4. Use of radii less than 900 m must be justified in the design report.

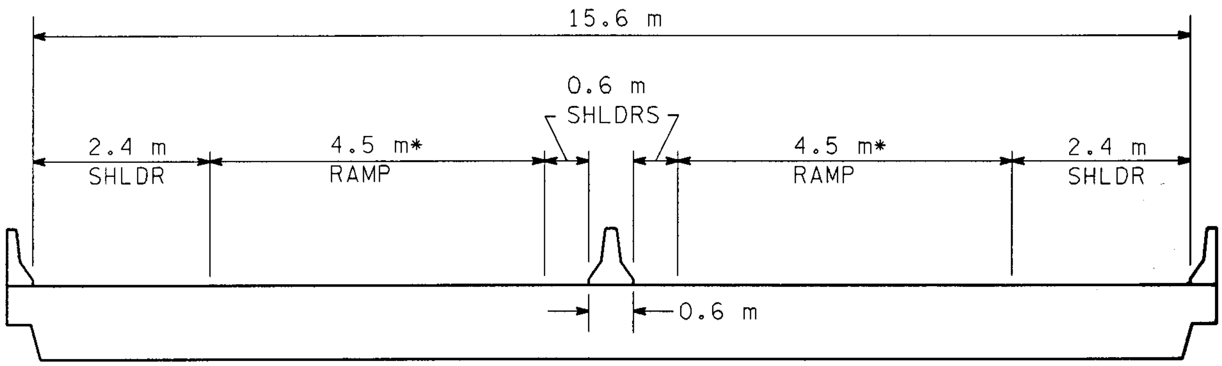


Two-Lane Ramp Meter With HOV Bypass

Figure 1050-4b

(Metric)

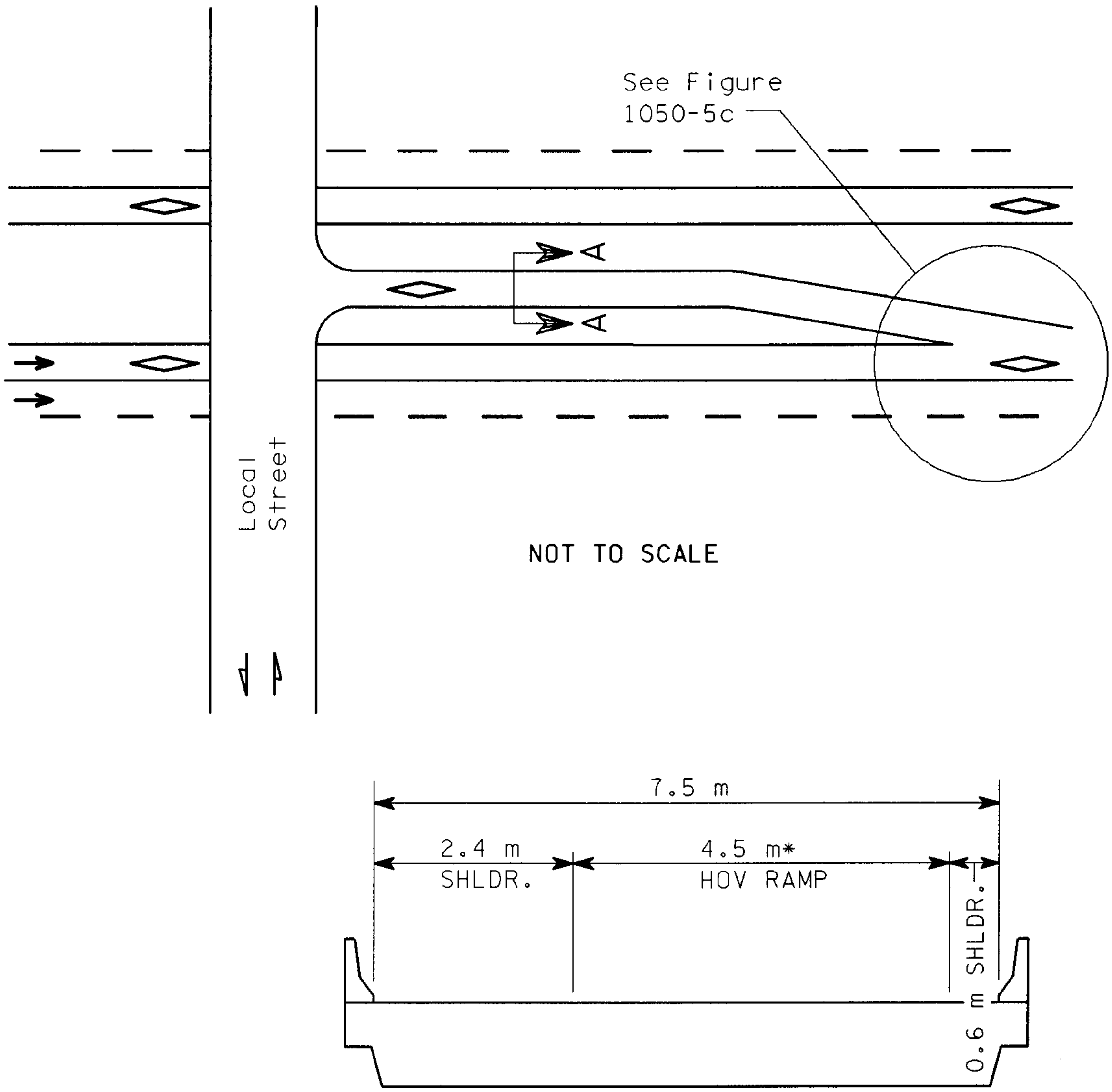




Section A-A

*See Chapter 640 for turning roadway widths.

Typical HOV Flyover
Figure 1050-5a
(Metric)

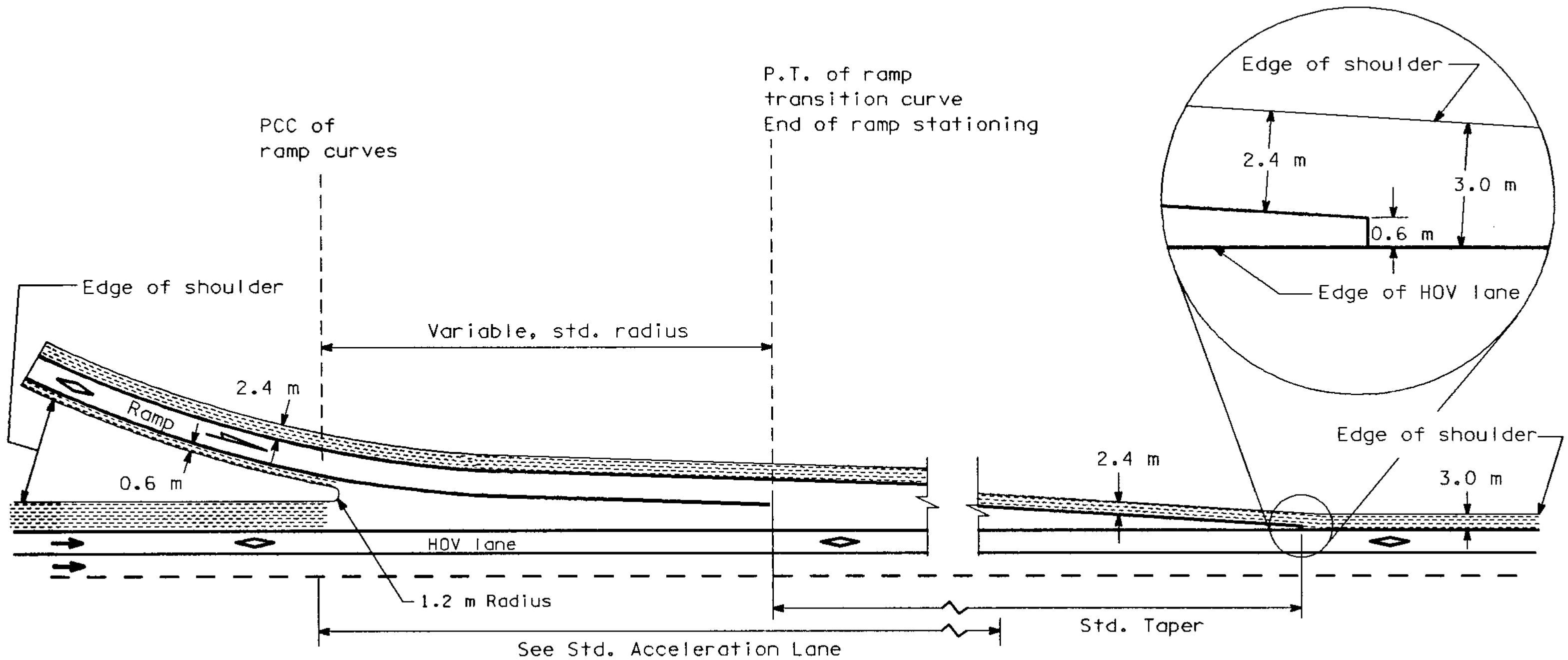


Section A-A

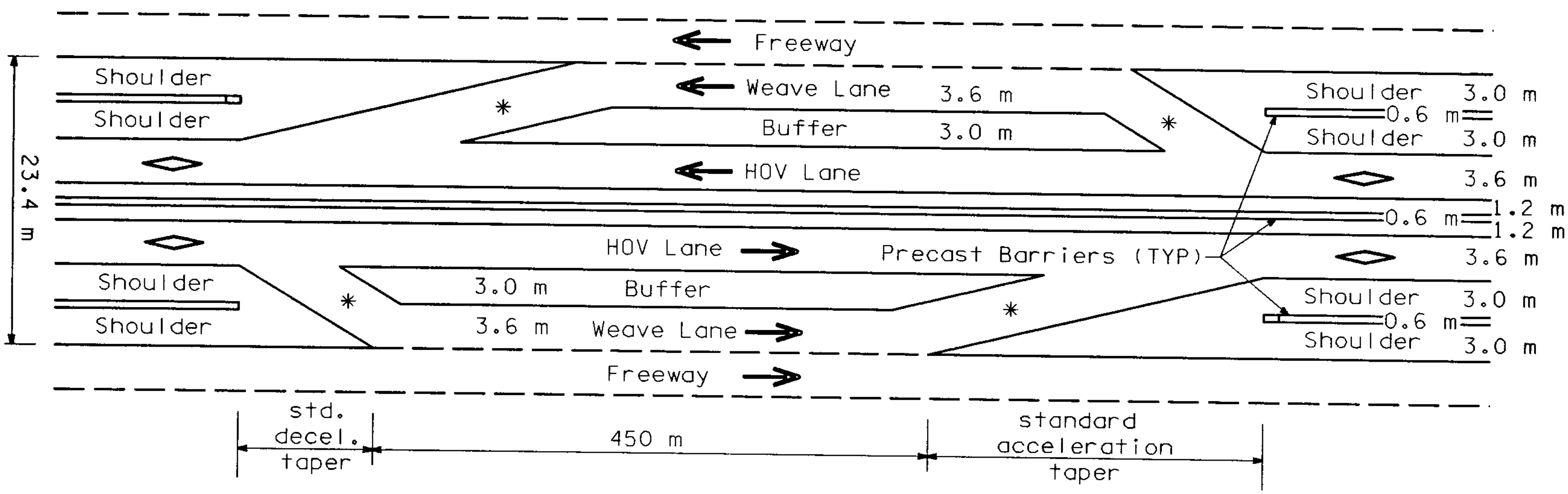
*See Chapter 640 for turning roadway widths.

Typical Inside Lane On Ramp
Figure 1050-5b
(Metric)

Inside Single-Lane On Ramp
Figure 1050-5c
(Metric)

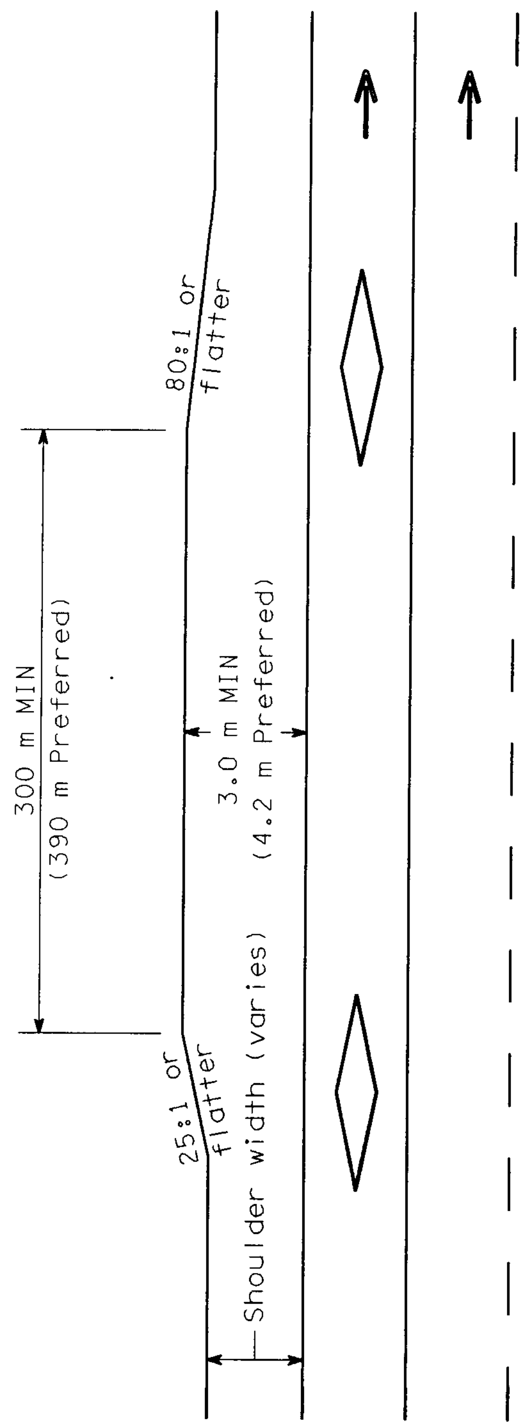


NOTE: See Chapter 940, "Single Lane On Connection".

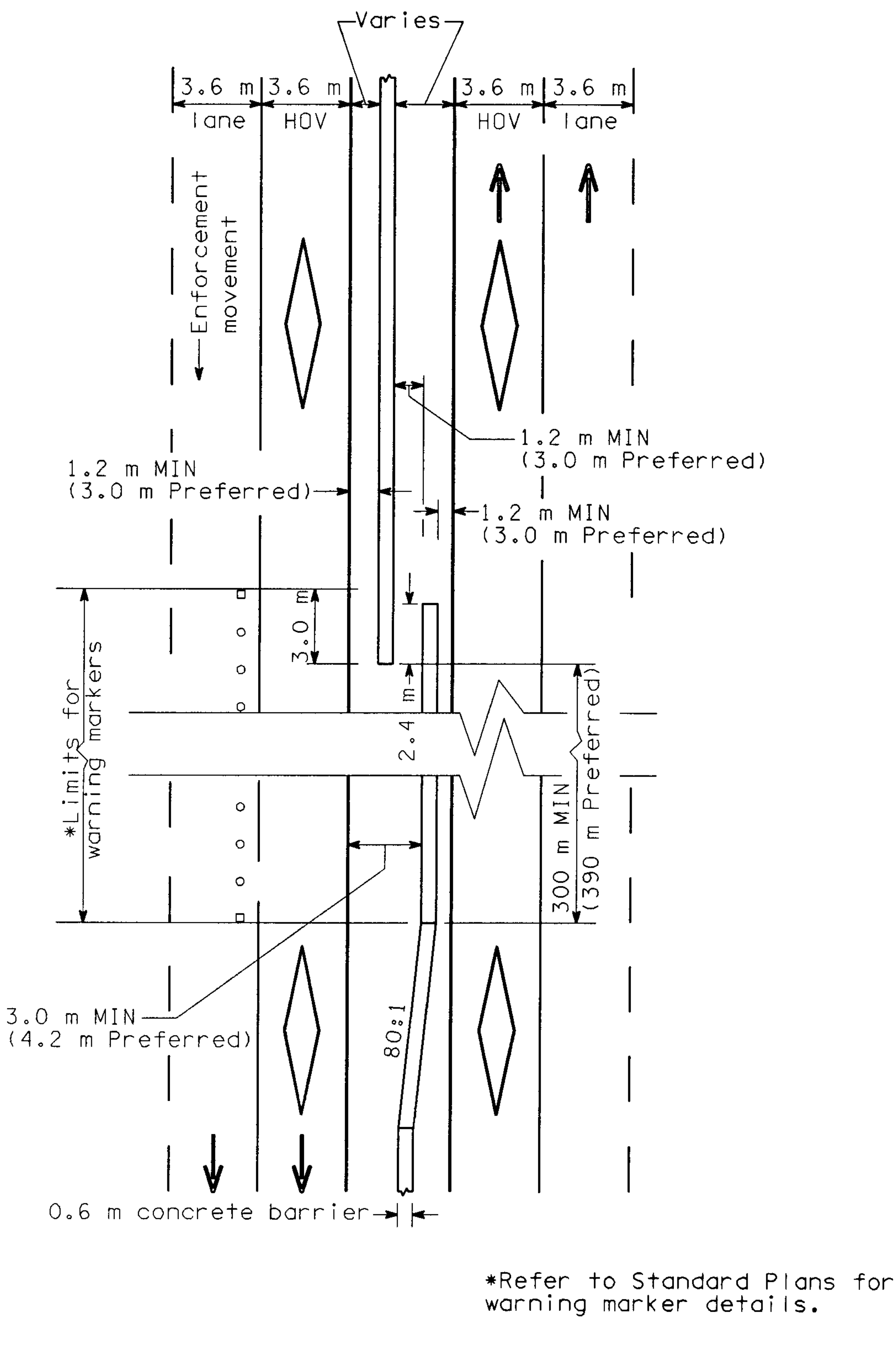


Typical Slip Ramp
Figure 1050-6
(Metric)

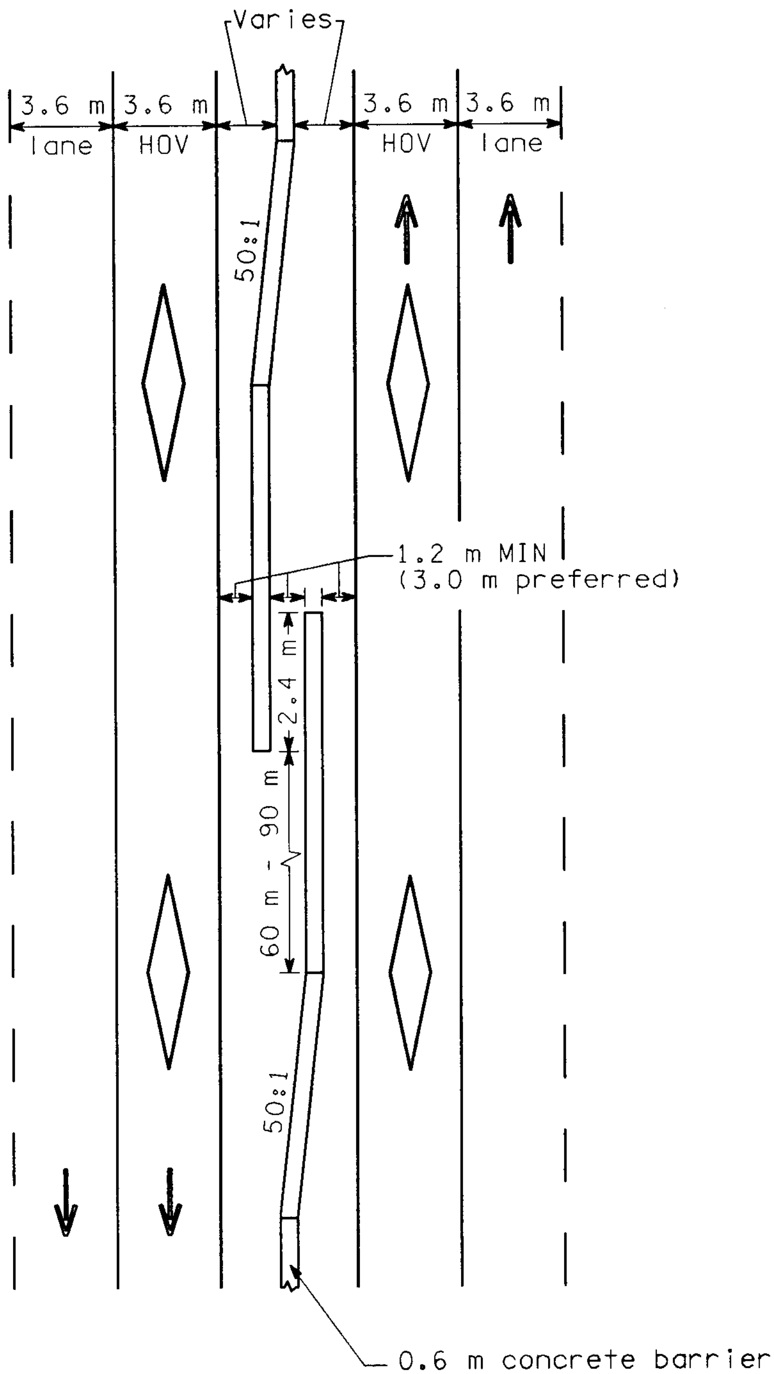
* For standard acceleration and deceleration tapers see Chapter 940.



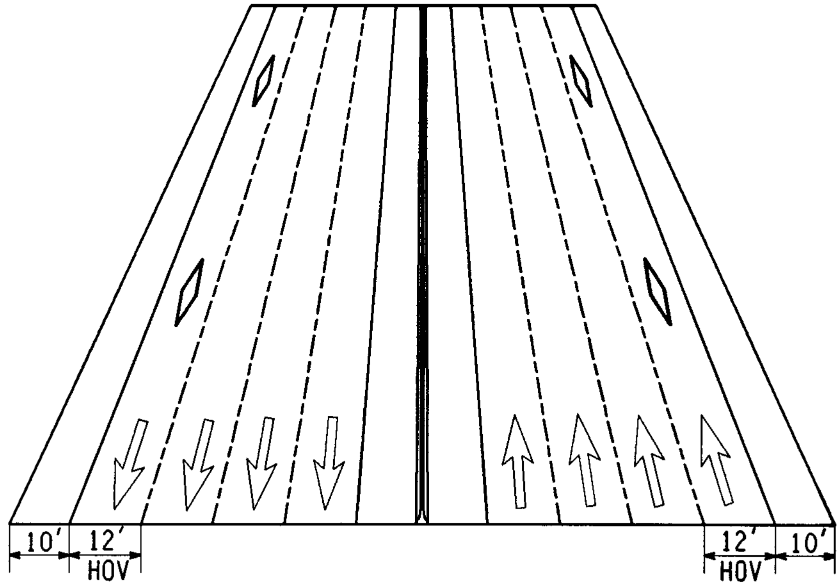
Enforcement Area (One Direction Only)
Figure 1050-7a
(Metric)



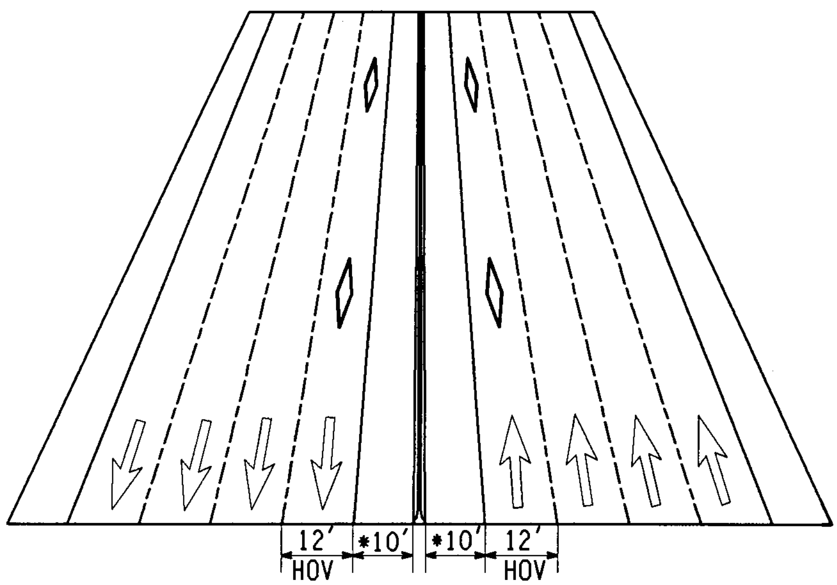
Median Enforcement Area
Figure 1050-7b
(Metric)



Bidirectional Observation Point
Figure 1050-7c
(Metric)



Concurrent flow HOV lanes with outside HOV lanes



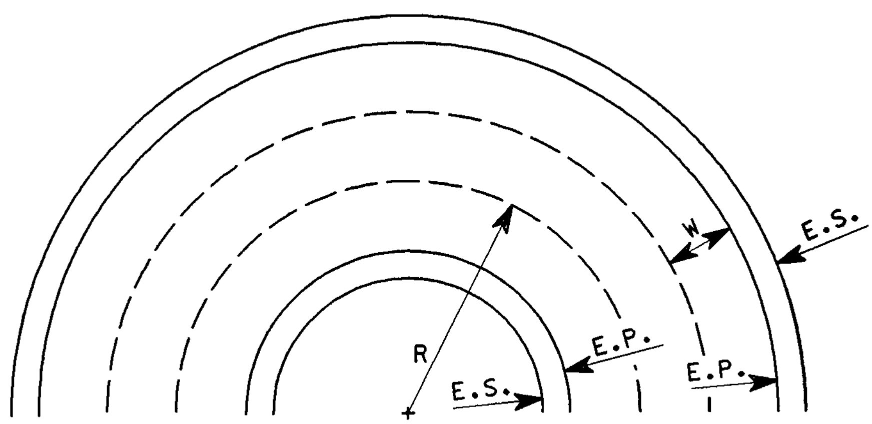
Concurrent flow HOV lanes with median HOV lanes

*For continuous lengths of barrier, a 10′ shoulder with a 2′ shy distance is recommended to provide an enforceable corridor.

Typical Concurrent Flow Lanes

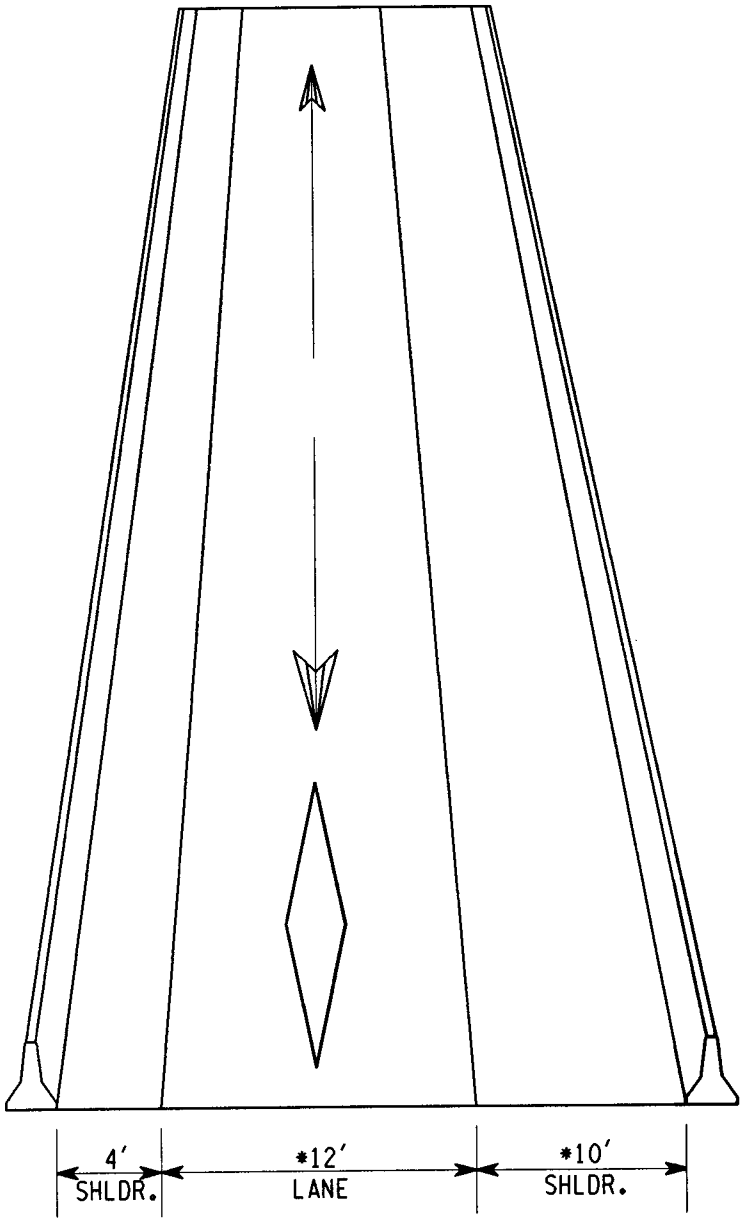
Figure 1050-1

RADIUS OF TWO-LANE RAMP R (ft)	DESIGN WIDTH OF THIRD LANE* W (ft)
1001 to TANGENT	12
1000	13
600	13
500	13
400	14
350	14
300	14
250	14
200	15
150	16
100	17



* NOTE: Apply additional width to 2-lane ramp widths.
See Chapter 640 for turning roadway widths.

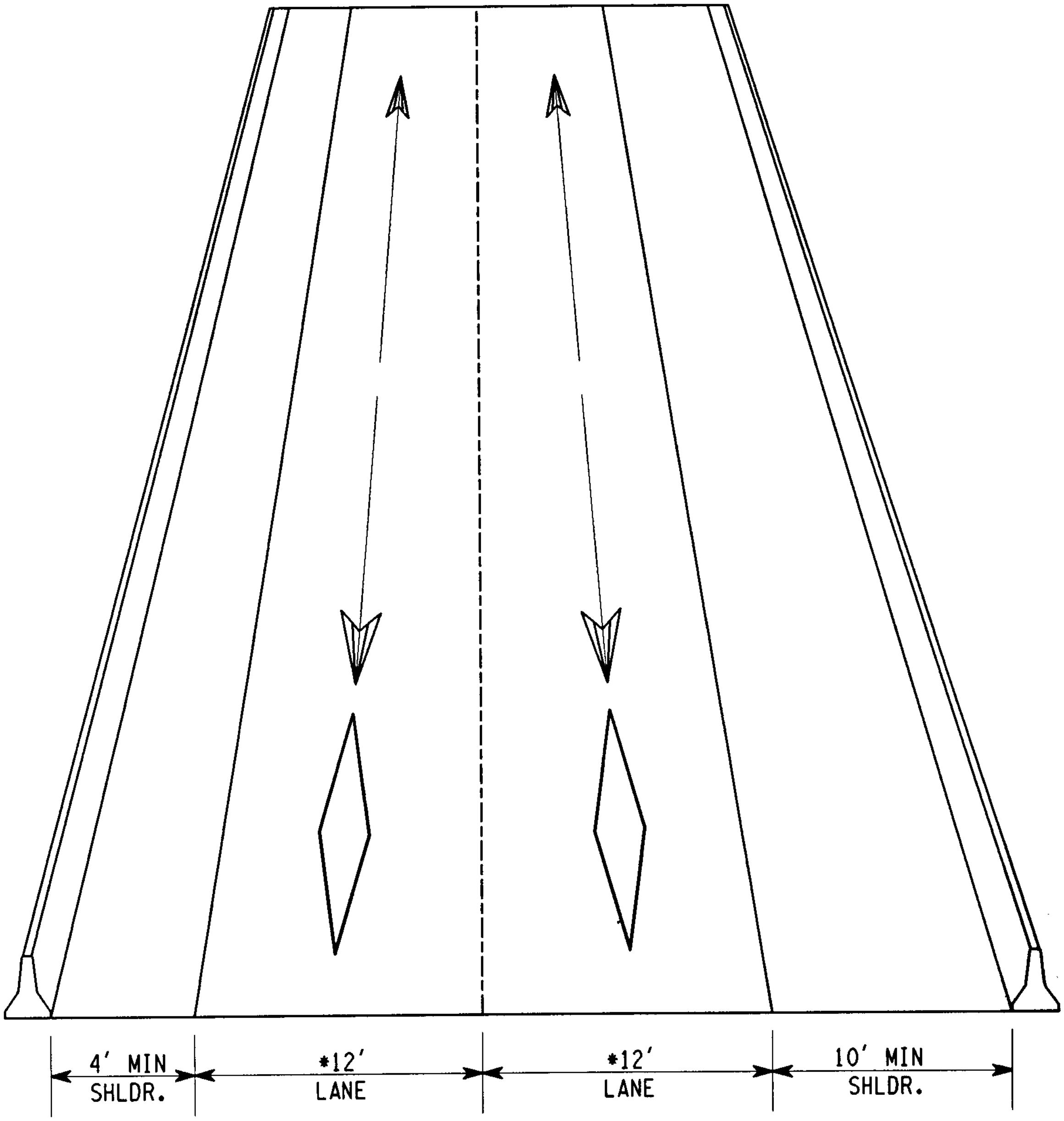
Roadway Widths for Three-Lane HOV On and Off Ramps
Figure 1050-2



*See Chapter 640 for turning roadway widths.

**The use of an 8′ shoulder will require a design deviation.

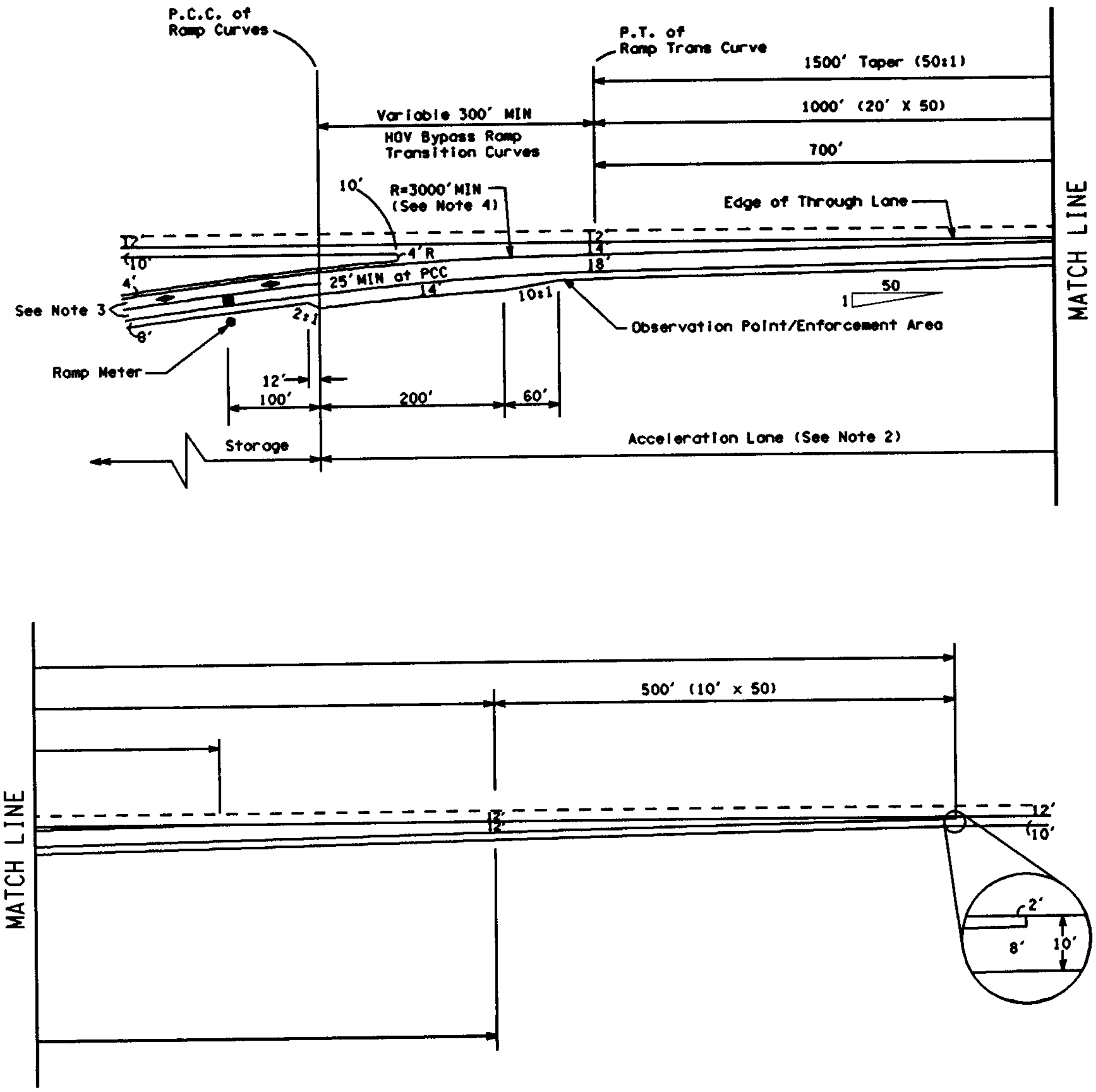
Separated Roadway Single-Lane, One-Way or Reversible
Figure 1050-3a



* See Chapter 640 for turning roadway widths.

Separated Roadway Multi-Lane, One-Way or Reversible
Figure 1050-3b

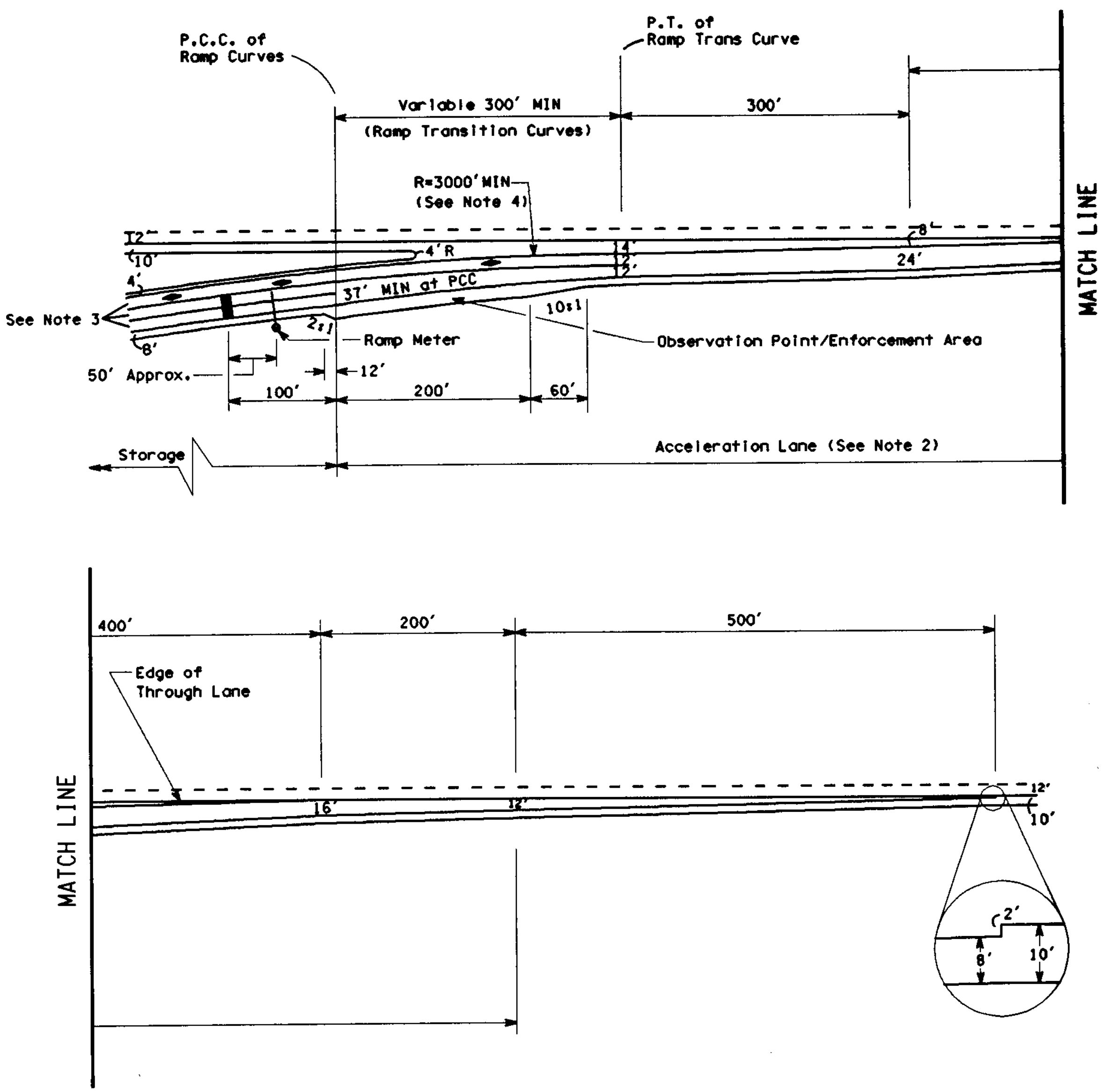
NOTES
1. See Standard Plans for Striping Details.
2. This distance must equal or exceed the "Acceleration Lane Length" tabulated in Chapter 940.
3. See Chaper 640 for roadway widths.
4. Use of radii less than 3000' must be justified in the design report.



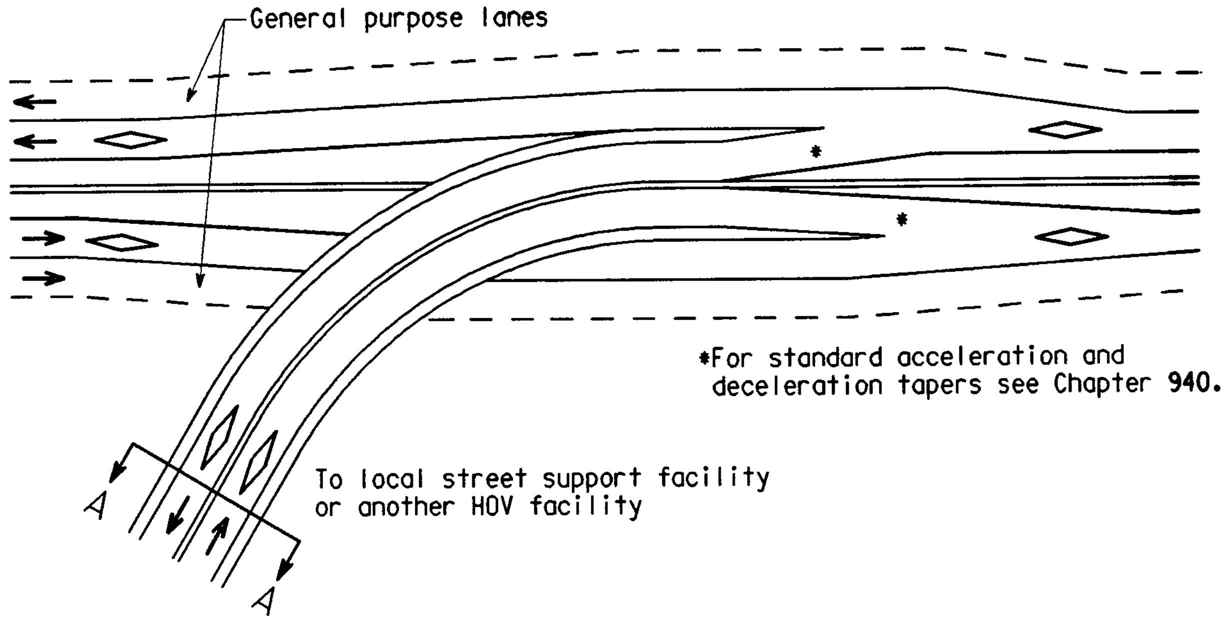
Single-Lane Ramp Meter With HOV Bypass

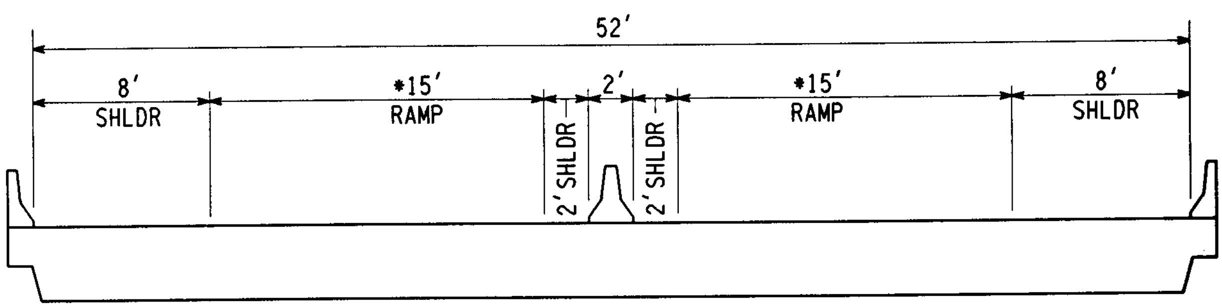
Figure 1050-4a

NOTES
1. See Standard Plans for Striping Details.
2. This distance must equal or exceed the "Acceleration Lane Length" tabulated in Chapter 940.
3. See Chapter 640 and Figure 1050-2 for roadway widths.
4. Use of radii less than 3000' must be justified in the design report.



Two-Lane Ramp Meter With HOV Bypass
Figure 1050-4b

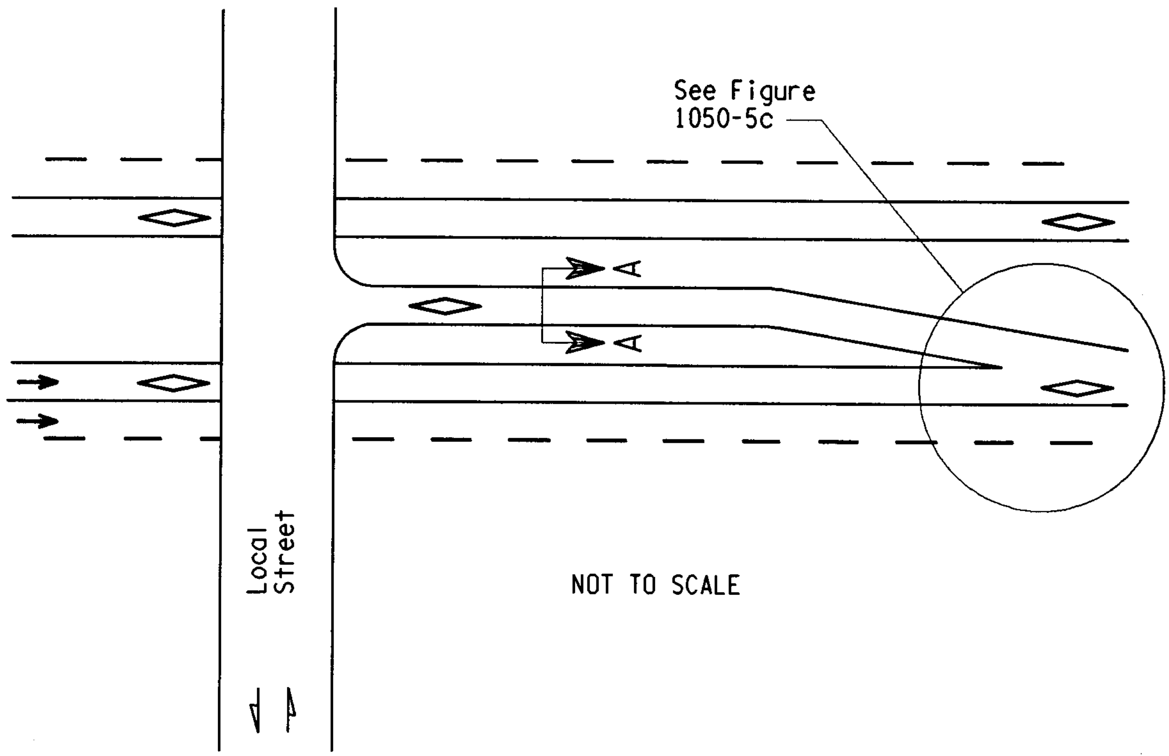


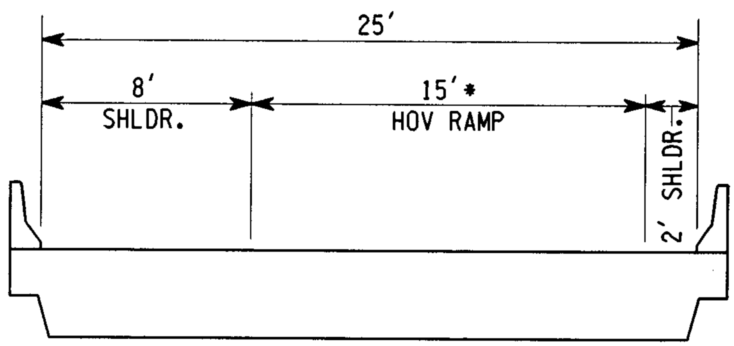


Section A-A

*See Chapter 640 for turning roadway widths.

Typical HOV Flyover
Figure 1050-5a



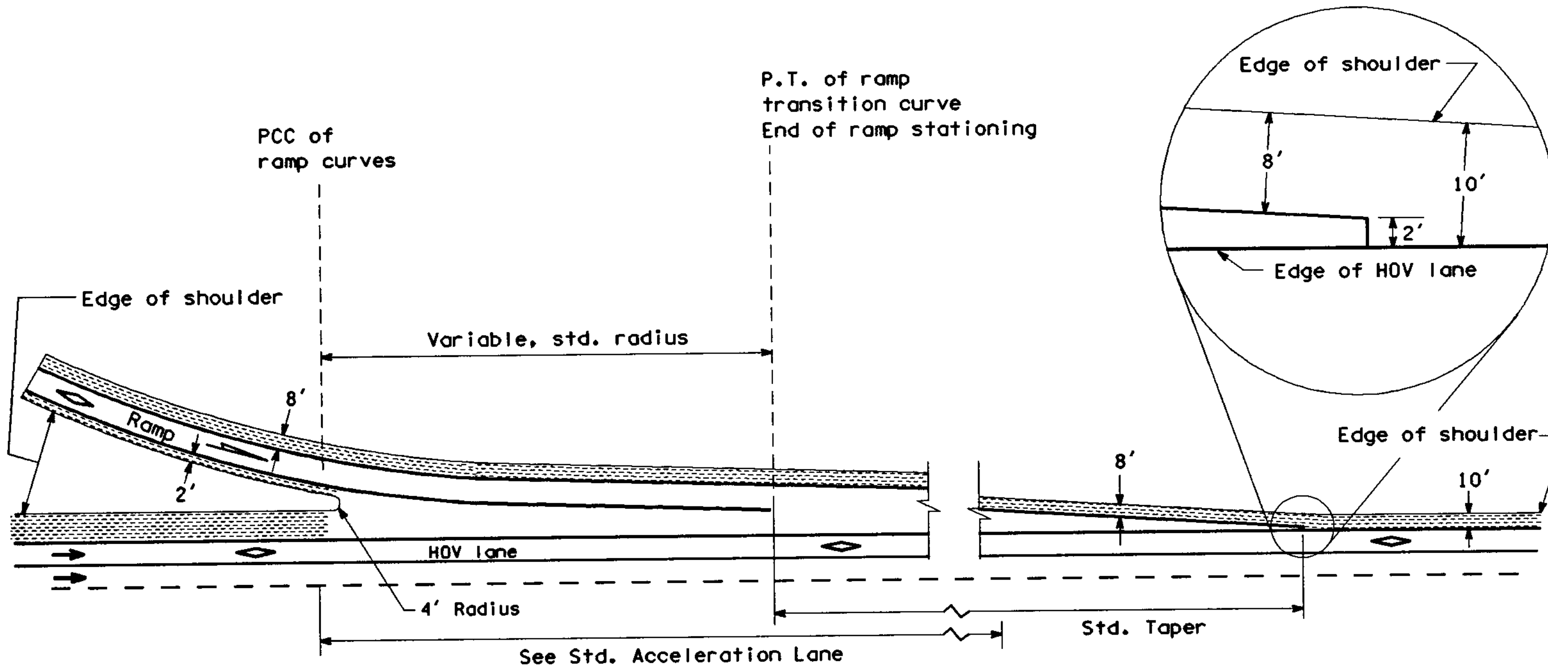


Section A-A

*See Chapter 640 for turning roadway widths.

Typical Inside Lane On Ramp

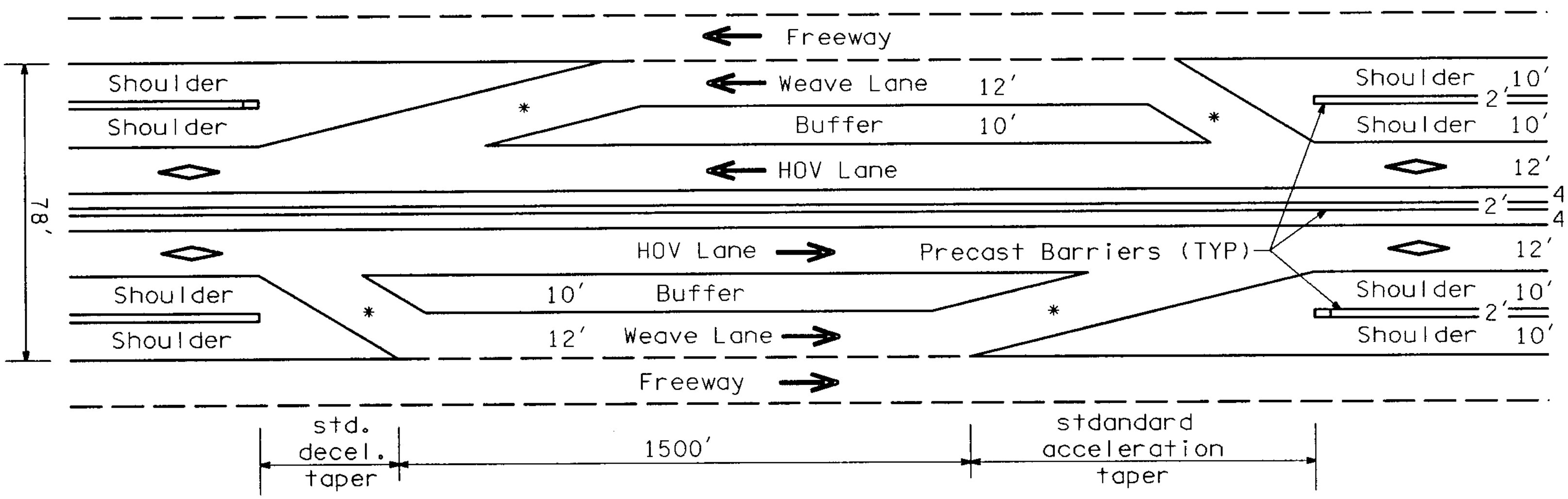
Figure 1050-5b



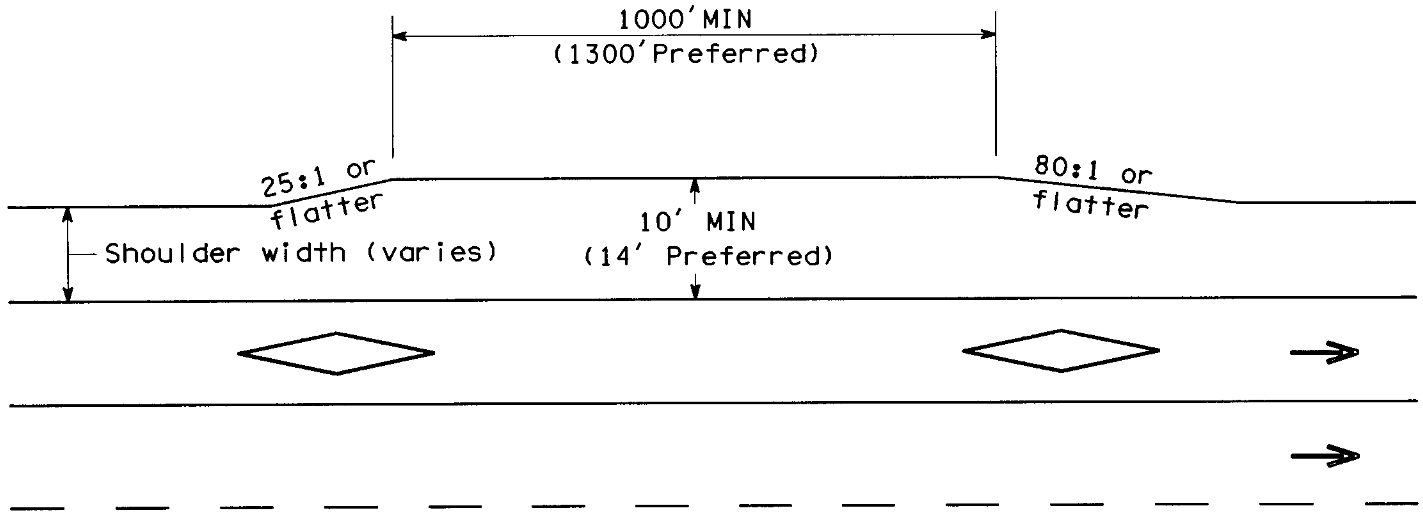
NOTE: See Chapter 940, "Single Lane On Connection".

Inside Single-Lane On Ramp
Figure 1050-5c

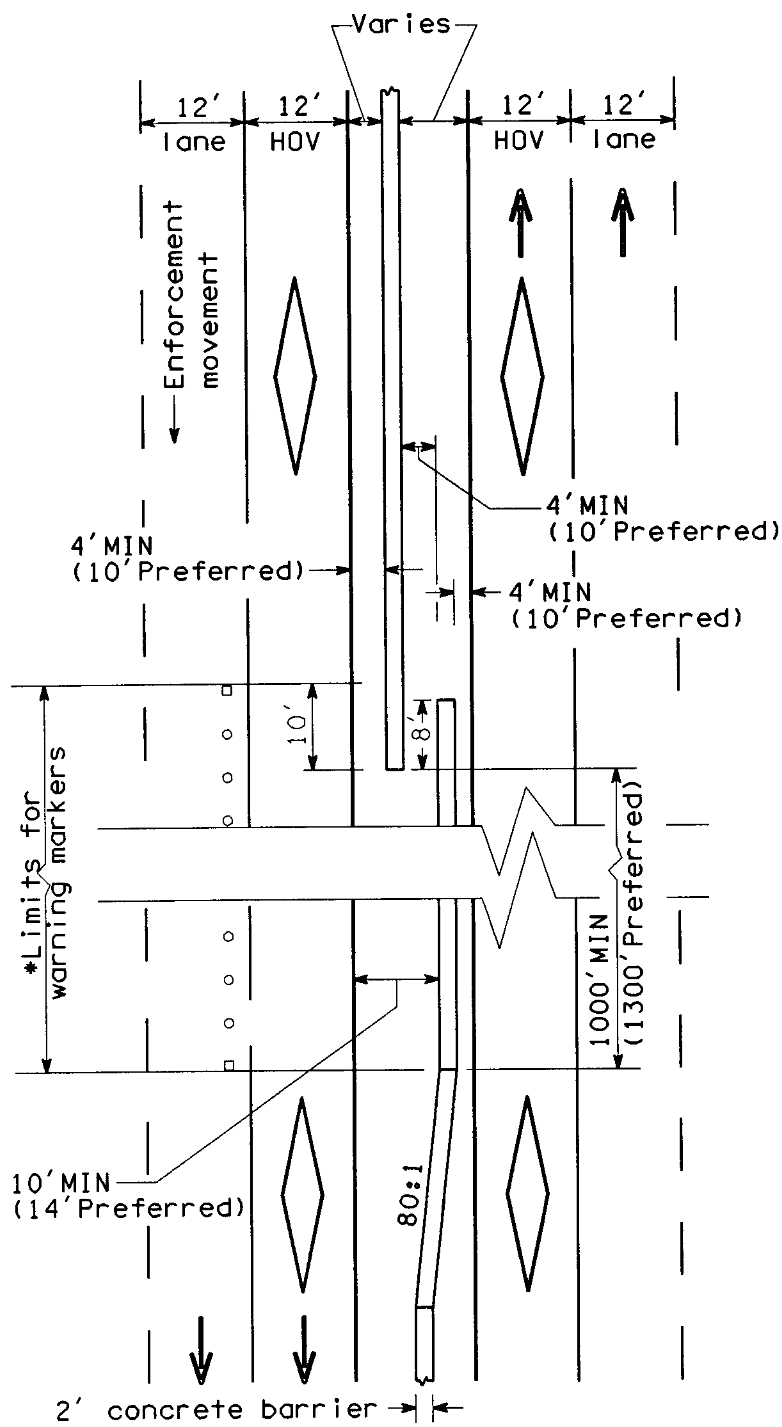
Typical Slip Ramp
Figure 1050-6



* For standard acceleration and deceleration tapers see Chapter 940.



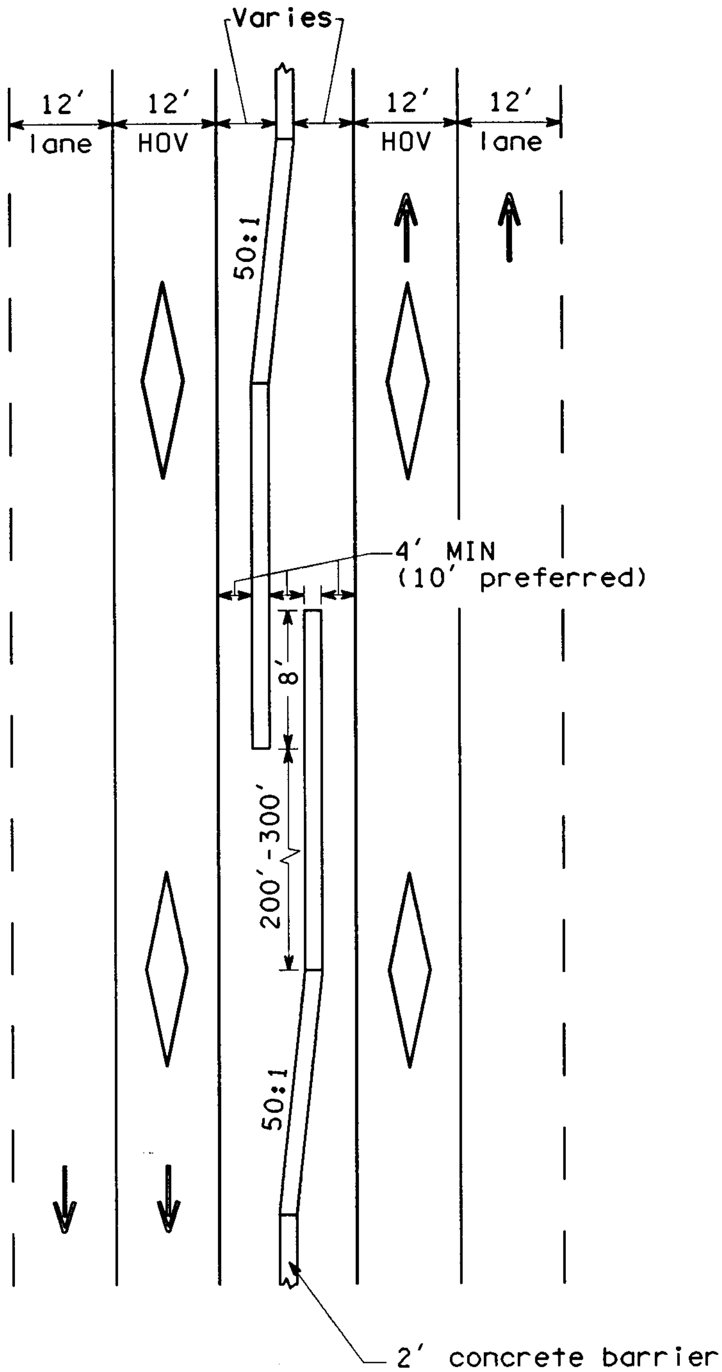
Enforcement Area (One Direction Only)
Figure 1050-7a



*Refer to Standard Plans for warning marker details.

Median Enforcement Area

Figure 1050-7b



Bidirectional Observation Point
Figure 1050-7c